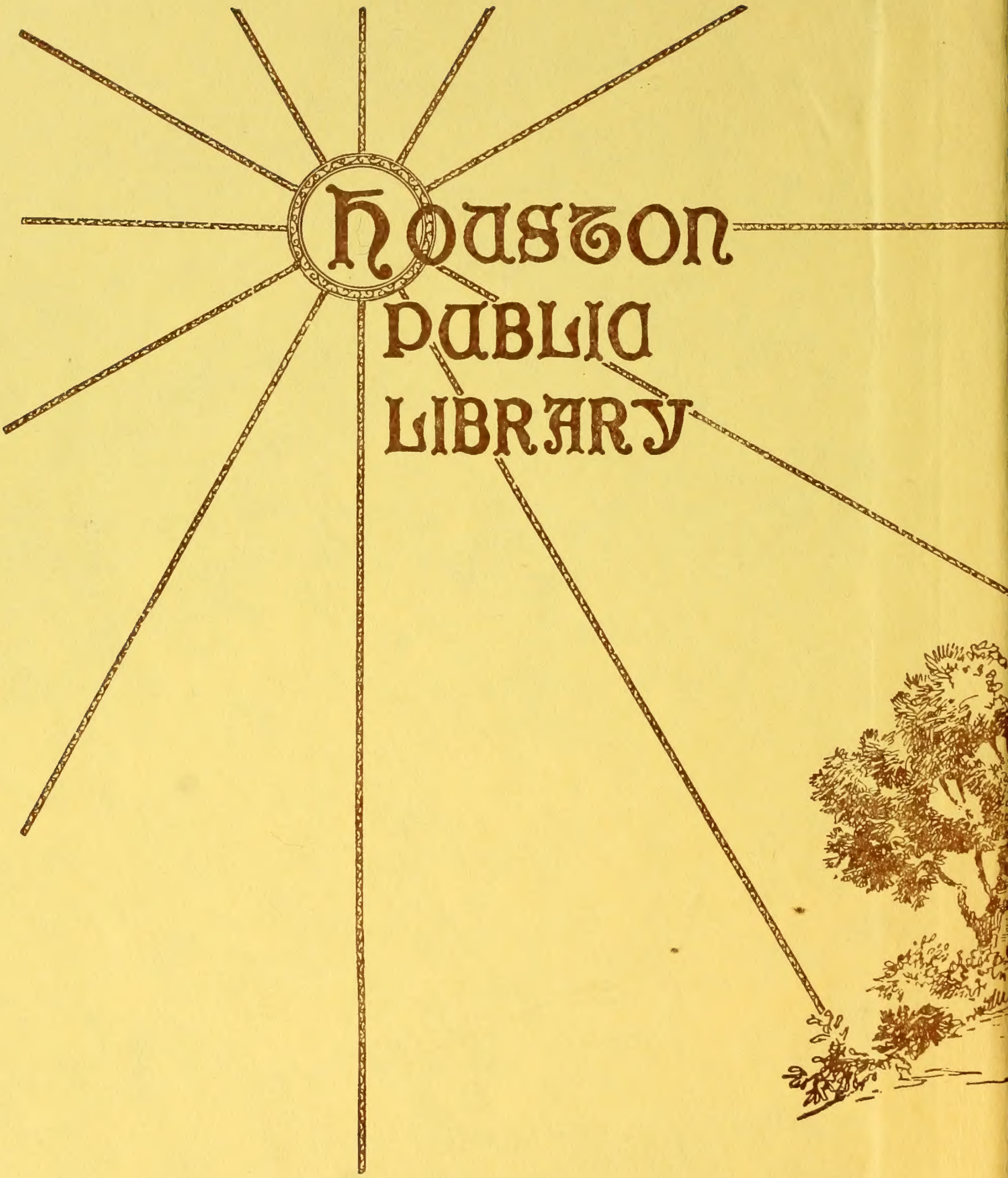

HOUSTON
PUBLIC
LIBRARY

DISC

Digitized by the Internet Archive
in 2014

http://archive.org/details/missilesrockets1619unse

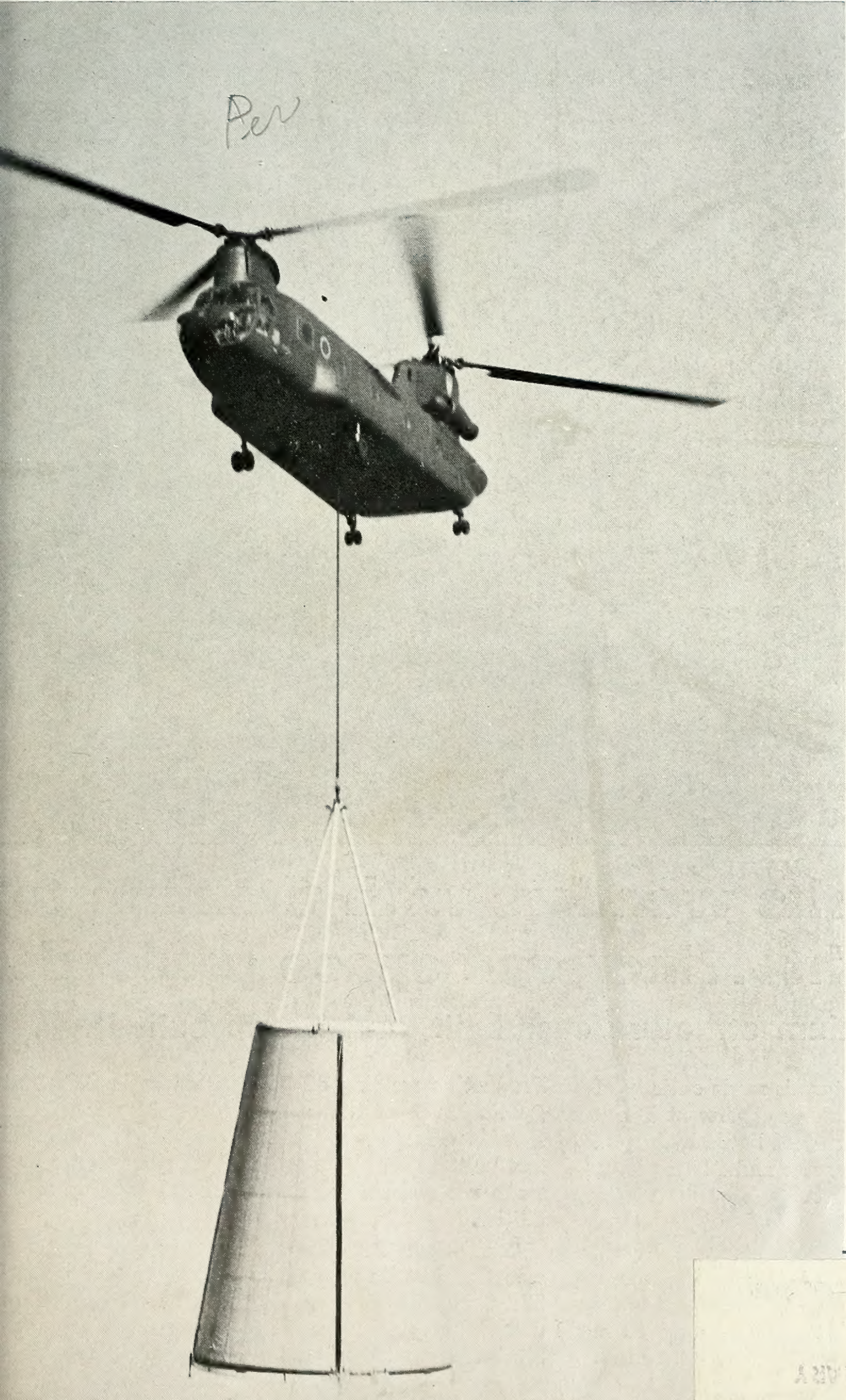
JANUARY 4, 1965

missiles and rockets

HE WEEKLY OF ADVANCED TECHNOLOGY

JAN 1965
HOUSTON PUBLIC
LIBRARY

Per



Nike-X Threat Analysis Study Completed

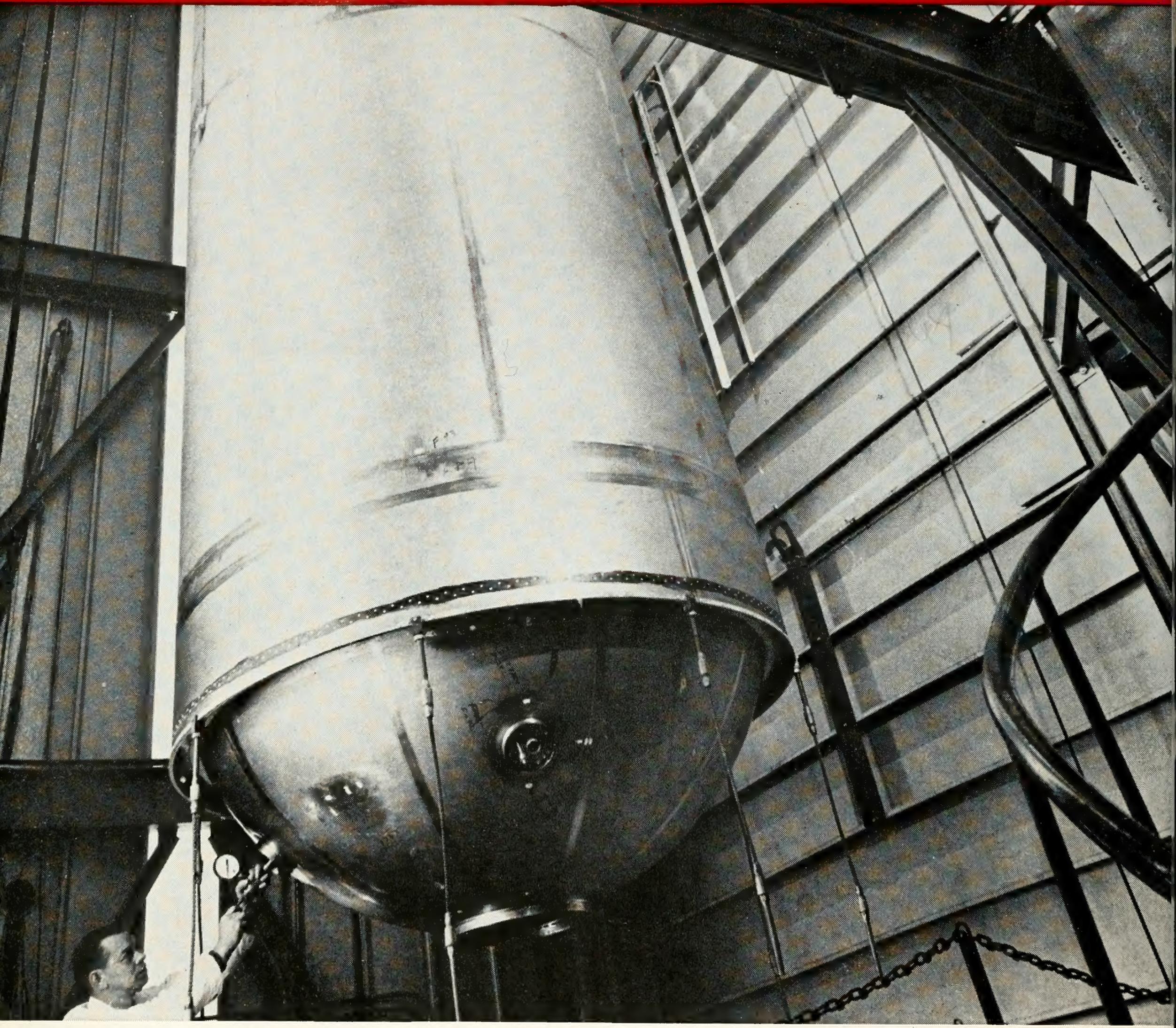
Huge Forging Press Planned

MOL Biomed Tests Defined

Cape's New Telemetry System

Dummy LEM Adapter Section Flown to Cape Kennedy

Beech "Imaginuity" in FABRICATION . . .



Beech works wonders with titanium to save weight . . . increase space payloads

Largest titanium structure ever built, and Beech built it.

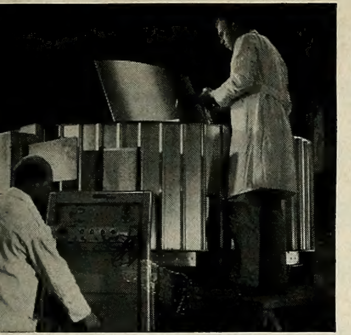
The large tank in this picture is made entirely of titanium. Built by metal-working experts at Beech to hold 7,000 gallons of pressurized liquid hydrogen, the tank is eight feet in diameter and 24 feet long. Weight savings are tremendous.

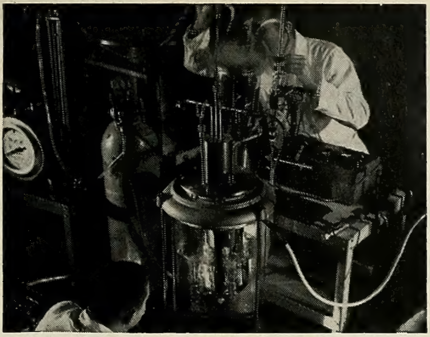
This means more payload.

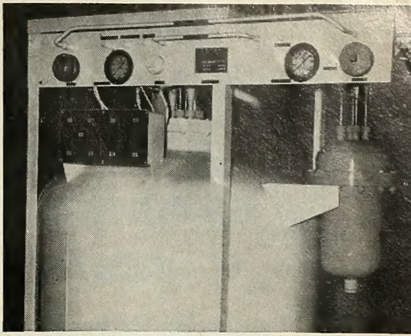
Fabricating titanium is an old story at Beech. And if it's something that's never been done before, that's not unusual. In this case the upper and lower hemispherical tank heads were chemically milled in a complex pattern to extremely close tolerances. Production welding of .012″ titanium is S.O.P. at Beech. Much of the equipment used by the Aerospace Division is one-of-a-kind and must be designed and built under the most rigid controls. Other jobs make use of Beech's extensive metal bonding capabilities.

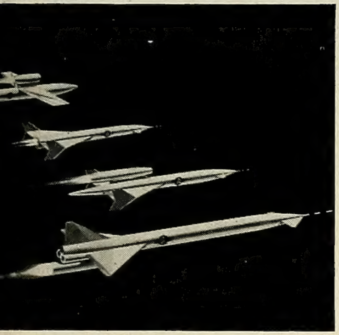
Sophisticated fabrication is one of the many elements that make up the comprehensive Beech capability. It's one reason Beech is well prepared to undertake complete systems management responsibilities for a wide range of space-age projects.

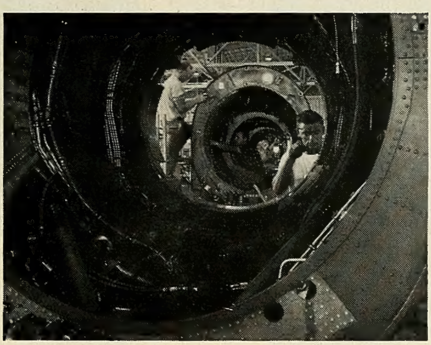
Other Beech Capabilities In Systems Management Include:

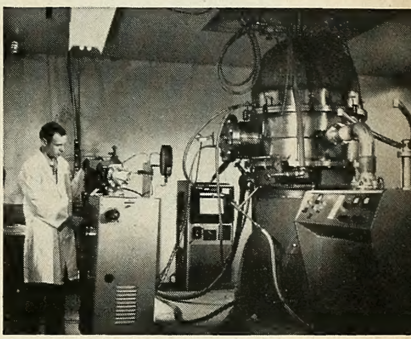

R&D...


Propulsion...

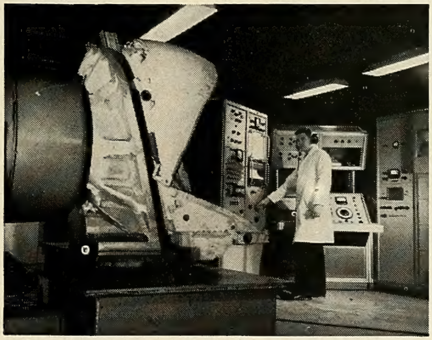

Auxiliary Power...

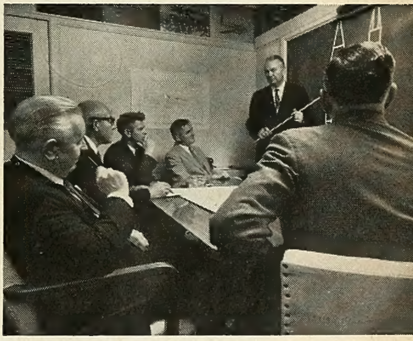

issile Target Systems...


Manufacturing...


Space Simulation...

acilities...


Complex Vibration...


Management...

How may we help you? To discover how the proven capabilities of the Beech organization can be quickly and efficiently put to work on your project, write, wire or phone Contract Administrator, Aerospace Division, Beech Aircraft Corporation, Wichita, Kansas 67201. Beech stands ready and eager to accept complete systems management responsibility for your project right now.

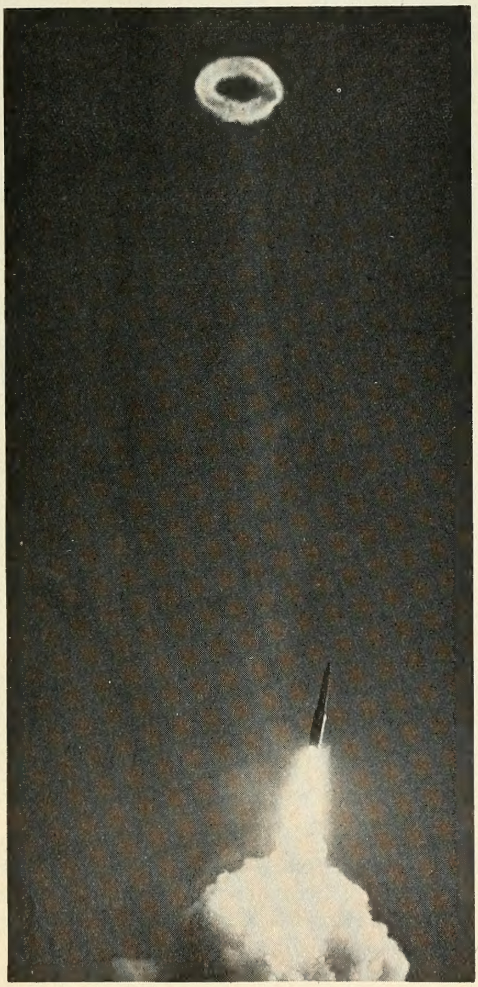
Beech *Aerospace Division*

BEECH AIRCRAFT CORPORATION • WICHITA, KANSAS 67201

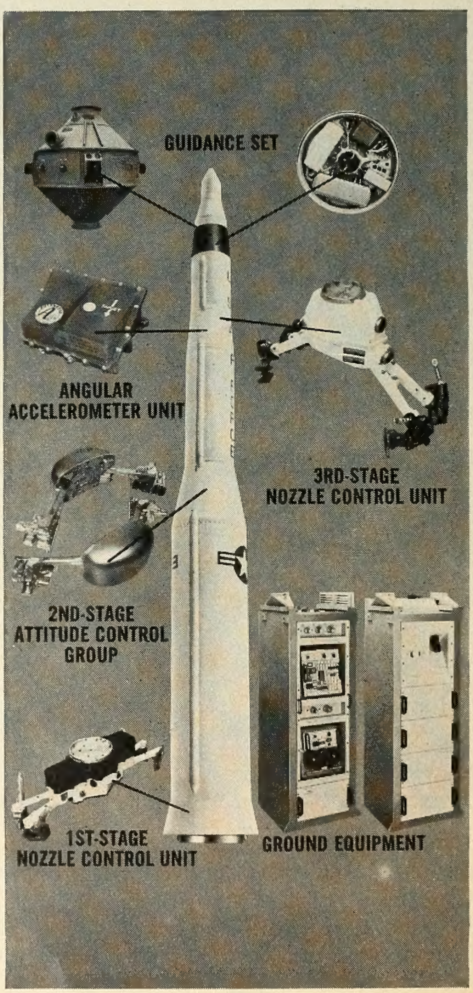
HELPING BUSINESS GROW FASTER: Only Beechcraft offers such a complete line of planes with so much speed, range, comfort and quiet to help business multiply the money-making decisions that each top man can make. That's how thousands of Beechcrafts have paid for themselves.

Executives: Write today for latest illustrated folders on ☐ Beechcraft twin-engine airplanes, ☐ Beechcraft single-engine airplanes. Address Beech Aircraft Corporation, Marketing Services Department, Wichita, Kansas 67201, U. S. A.

MINUTEMAN II SCORES COMPLETE SUCCESS ON 5000-MILE MAIDEN TEST FLIGHT



IT WAS THE FIRST MISSILE FLIGHT WITH FULLY-INTEGRATED MICROELECTRONICS SYSTEMS


GUIDANCE SET
ANGULAR ACCELEROMETER UNIT
3RD-STAGE NOZZLE CONTROL UNIT
2ND-STAGE ATTITUDE CONTROL GROUP
1ST-STAGE NOZZLE CONTROL UNIT
GROUND EQUIPMENT

The first flight of the Minuteman II represents a breakthrough in the application of microelectronics to military and space systems. The guidance, control, and checkout systems for the Minuteman II were designed, developed, and produced for the U. S. Air Force by NAA/Autonetics and its nationwide team of suppliers.

North American Aviation **Autonetics Division**

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 1 January 4, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors
Charles D. LaFond................Electronics
William S. Beller................Engineering

Associate Editors
Lawrence J. Curran......Assistant Managing Editor
Heather M. David.................Space Medicine
Michael Getler.......................Electronics
Russell Hawkes.........................Industry
John F. Judge.................Advanced Materials
Robert L. Parker......................Copy Editor
Rex Pay..............................Electronics
Hal Taylor...............................NASA
James Trainor.........................Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach...................Art Director
Donald Strickland............Assistant Art Director
Suzanne Montgomery............Editorial Assistant
Sally Fosnight...................Editorial Assistant

BUREAUS
LOS ANGELES.....9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks..................Bureau Chief
NEW YORK...................20 East 46th Street
Michael Getler
CAPE KENNEDY................507 Orange Ave.
Chris Butler....................Merritt Is., Fla.
MIDWEST........................423 N. Quentin
John L. Zimmerman..............Wichita, Kan.
PARIS..........................11 Rue Condorcet
Jean-Marie Riche
GENEVA..........................10 Rue Grenus
Frank G. McGuire

EDITORIAL ADVISORY BOARD
Dr. Peter Castruccio **Alexander Satin**
Conrad H. Hoeppner **Vice Adm. H. Sanders (ret.)**
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton............National Sales Manager
Paul B. Kinney........Eastern Advertising Manager
Edwin J. Denker, Jr......Western Advertising Manager
Kenneth C. Blanchard.Marketing & Research Director
John N. Carlin..............Director of Circulation
Paddy Nelson................Circulation Promotion
R. Virgil Parker............Director of Production
Barbara Wiener........Advertising Services Manager
Cynthia Livingstone...........Production Assistant

Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President..........................**Wayne W. Parrish**
Senior Vice President.................**Louis C. James**
Vice President........................**Fred S. Hunter**

THE COVER

Dummy section of Lunar Excursion Module during record flight from Tulsa, Okla., to Cape Kennedy, Fla. Adapter section was built in Tulsa by North American Aviation, Inc.'s Space and Information Systems Div., and weighs 2½ tons. It was delivered to the Cape Dec. 29 by an Army Chinook CH-47 helicopter.

➠ JANUARY 4 HEADLINES

Minuteman Procurement Cut by 200 in FY '66 Budget ... 10
Boeing Chosen for Saturn V Systems Integration 10
ComSat's Early Bird Launch Scheduled for March 10
Threat Analysis Study Bolsters Case for Nike-X 12
Space Agency Gives Voyager Development Go-Ahead ... 13
Preview of Aerospace Outlook in 89th Congress 14
Huge Forging Press Awaits DOD Production Nod 15

➠ SPACE SUPPORT

IR Thermography Aids Non-Destructive Testing 22
Manned Gemini-Type Glider Flight Is Successful 31

➠ SPACE MEDICINE

Beckman Study Aimed at Space Station Instrumentation . 26

➠ SPACE ELECTRONICS

ETR Telemetry System May Set Pace for Decade 32
Ionosphere Satellites Refining Long Antennas 34

➠ DEPARTMENTS

Letters 6
The Countdown 9
The Missile/Space Week® 10
Technical Countdown .. 21
Products & Processes .. 37
The Industry Week 41
Contracts/Procurements 42
Names in the News 44
When & Where 45
Editorial 46

48,000 copies this issue

YOUR OWN

PEACEFUL TROPICAL ISLAND PARADISE ON GRAND BAHAMA!

Just 50 miles (80.5 km) across the Gulfstream from Palm Beach, Florida, lies beautiful tropical GRAND BAHAMA ISLAND.

Become part of the social and community life in the fastest growing island in the Bahamas. Grand Bahama has three 500-room hotels and more building...luxury apartment blocks . . . churches, schools, stores, businesses...medical, dental and hospital facilities ...two championship golf courses ...casino...cinemas...marinas... world-famous fishing and skin diving...and booming industrial Freeport. Over 20 scheduled flights daily from Florida, plus steamer service. Adjacent to all this growth on Grand Bahama Island, we are offering a limited number of choice homesites.
Choose yours now!

HOMESITES: *From $75 down— $75 on closing (within 90 days) balance from $15 monthly on mortgage note.

*Will accept any currency at its official bank conversion rate

• NO LAND TAXES • NO BAHAMAS INHERITANCE TAXES • NO RESTRICTIONS ON PERMANENT RESIDENCE ON YOUR OWN LAND • NO CLOSING COSTS • FREE DEED • FREE TITLE INSURANCE •

AIR MAIL COUPON NOW!

SUNSHINE REALTY
777 Metropolitan Miami Building
Dept. MR-3 , Miami, Fla 33132
PLEASE SEND FULL INFORMATION

Name________________________

Address_______________________

City__________________________

State______________Zip Code________

Circle No. 5 on Subscriber Service Card

memo from the publisher

EFFECTIVE WITH THIS first issue of MISSILES AND ROCKETS for 1965, we have made a change in our subtitle. The Weekly of Advanced Technology more aptly describes the coverage job we have been doing for the last year and allows us to continue to provide you with information on nuclear and anti-submarine warfare engineering—to name only two of the many areas in which the systems management ability developed by firms in the Missile/Space field is becoming increasingly important.

Actually, this is not a change on our part, since we have been reporting in these and other areas for some time, in keeping with our policy of informing our readers of the various changes in the market and the new opportunities for applying their technology.

The vast knowledge acquired by Missile/Space firms in all areas of advanced technology is one of the nation's most valued resources. It will be used in many areas other than armament in the months and years ahead. Our aim is to continue to keep you, our readers, up to date with the state of the art and its relation to the desires of the Government and industrial customer.

Another move to further strengthen our editorial team has been the addition of a Midwestern news bureau, located in Wichita, Kansas. John Zimmerman, one of the top Missile/Space reporters in the Midwest, has been named to head the bureau and will devote full time to coverage of activities throughout the region.

You will also be reading more about the international market in MISSILES AND ROCKETS in the weeks ahead. We have arranged a rather extensive travel schedule for our editors to visit all parts of the world during 1965 to keep you abreast in the many technical areas in which organizations throughout the free world are engaged.

ALL IN ALL, we look for a year of growth and prosperity for alert firms engaged in the Missile/Space field. We see a continued healthy trend of spending in the general area of defense and space exploration, as well as many new markets for your products and talents. In fact, we think current trends toward the utilization of advanced technology in government activities other than defense should come as good news to those firms whose livelihood has always hinged on the nation's defense posture. Advanced Technology is the key to future business. Firms that aggressively exploit the new opportunities will indeed continue to grow and prosper—while serving, as they always have, the interests of the nation's Government.

James W Claar

ENGINEERS:

Design and Development openings at Boeing

Boeing, world leader in advanced swept-wing, multi-jet aircraft, is today pioneering evolutionary advances in both civilian and military aircraft fields. These programs have created outstanding openings in the Pacific Northwest with Boeing's Airplane Division for graduate engineers at all experience levels in the fields listed below. Minimum educational requirement is a B.S. degree in an engineering discipline, except where noted.

DESIGN

Structural—Duties include the determination of aircraft structural requirements, preliminary sketches and preparation of final layout drawings and investigation.

Hydraulic—Duties include design of hydraulic systems and hydraulically actuated mechanisms, including brake-flaps, spoilers, landing gear doors, landing gear and nose wheel mechanisms.

Air Conditioning & Pneumatic Systems—Positions include the design of air conditioning and pneumatic systems, cabin heating and ventilation, cabin pressurization, electronic equipment cooling, and temperature control of aircraft surfaces.

Aircraft Control—Duties involve design of controls including ailerons, elevators, rudder, trim tabs and engine controls.

Power Plant—Assignments involve the design of engine installations, engine accessories, strut and engine supports, engine nacelles, and thrust reversers / sound suppressors.

Fuel Systems—Positions include design of fuel systems, fuel and tank ventilation systems, water injection and tank purging systems.

DEVELOPMENT

Structural Dynamics—Duties involve analysis and experiments in aeroelastic fields of flutter and dynamic loads. B.S. or advanced degree required in applied mechanics with significant aerodynamic and structures background related to high-speed aircraft. Should be familiar with latest theories and techniques for analysis and test.

Stability and Control—Openings require strong background in airplane flight control system design and analysis, and stability and control characteristics, plus knowledge of computers, servomechanism design and development and testing of airplane configurations. Master's degree or equivalent.

Flight Control Systems—Positions involve establishing dynamic design criteria and specifications for flight control systems, subsystems and components; selection of most suitable control system components, and guidance of control system procurement and flight test. Requires B.S. or M.S. in engineering, mathematics or physics with applicable experience.

Metallurgy and Mechanical Engineering—Assignments entail alloy selection and application, development and improvement of processes, preparation of specifications, laboratory experiments, technical consultation, and service failure analysis. Requirements, in addition to experience in aircraft technology or a related field, include familiarity with the electron microprobe and microscope and standard metallurgical equipment.

Chemical Engineering—Openings require experience in lubrication materials and concepts; elastomeric, inorganic finish, and organic polymeric materials, and structural adhesive bonding, plus a basic knowledge of materials behavior. Work involves evaluation, analysis and investigation of all materials characteristics, including mechanical, electrical, chemical and surface.

Propulsion—Responsibilities include research and development, primarily V / STOL oriented, in the fields of subsonic and supersonic inlets, thrusting ejectors and engine fan thrust vectoring; engine cycle analysis, engine / airplane optimization studies for subsonic and supersonic propulsion systems, and VTOL propulsion technology.

Salaries are competitively commensurate with your education and experience background. Travel and moving allowances are paid to newly hired personnel. Boeing is an equal opportunity employer.

Assignments are at Airplane Division's Renton Branch, located near Seattle in the uncongested Pacific Northwest, noted for year-round mild climate, famous recreational facilities, excellent schools and housing, and healthful outdoor Western living for the whole family.

Send your resume today to Mr. Thomas Sheppard, Airplane Division, The Boeing Company, P.O. Box 707-BAA, Renton, Washington 98055.

BOEING

AIRPLANE DIVISION

Other Divisions: Aero-Space • Vertol • Turbine • Also, Boeing Scientific Research Laboratories

This is DEI's Solid State Receiver

It's new
Tunes in the range of 100 to 2300 mc
Superior performance characteristics
The TR-711 is virtually spurious free
Sets the standard for comparison

SWEEP WIDTH
GAIN
FREQUENCY
TUNING
AM/FM DEMODULATOR
IF BANDWIDTH
SELECTOR
DEI
AUDIO GAIN
VIDEO FILTER BANDWIDTH

The TR-711 Receiver is modular in construction and can be supplied with a complete complement of plug-in modules including RF tuning units from 100 to 2300 mc, IF amplifiers with 10 kc to 3.3 mc bandwidths, AM, FM, and phase demodulators, and plug-in spectrum display unit, oscilloscope, predetection up and down converter, or high capture ratio discriminator. Any combination of plug-in modules can be utilized, thus providing unlimited receiving combinations adaptable to any known or projected telemetry system.

Characteristics and accessories are described in Bulletin TR-711.

Defense Electronics, Inc.
Rockville, Maryland

DEI
RESEARCH
DEVELOPMENT
MANUFACTURING

ROCKVILLE, MD. (301) 762-5700, TWX: 301-427-4660; **SHERMAN OAKS, CALIF.** (213) 872-2870, TWX: 213-732-2742; **COCOA, FLA.** (305) 632-5442; INT'L., **ROCKVILLE, MARYLAND.**

Circle No. 18 on Subscriber Service Card

The Countdown

WASHINGTON

Army Has Not Requested Nike-X Production

A top Army official says *Nike-X* is not yet at the point vhere technical progress dictates that failure to produce he system would result in obsolesence. The Army has not ecommended a production commitment to *Nike-X* in Fiscal 966. But it apparently lost the debate with Secretary of Defense McNamara for pre-production engineering funds.

DOD Plans Take-Over of Syncoms

Unless someone can think of a real good reason why not, he Defense Dept. will assume control of the *Syncom* satelites now in orbit. NASA and DOD are exploring this and n agreement seems likely. *Syncom II* has been in use by DOD for communications to Viet Nam for some time. *Syncom III*, used for the 1964 Olympics, will be used to speed nilitary traffic between the U.S. and Japan.

DOD and NASA To Continue MOL Studies

Dept. of Defense and NASA have agreed to continue tudies aimed at avoiding any duplication of NASA work by he Air Force's *Manned Orbiting Laboratory* program. They vill also continue studies of various configurations until April. The agreement will be announced by President John-on in his budget message to Congress later this month. Air Force officials confirm, however, that no matter what the tudies show regarding tradeoffs of the *Gemini/Titan III* s. *Apollo/Saturn IB*, the go-ahead for the military program as been given.

NASA Rejects Project Orion Proposals

The space agency does not plan to spend any further unds on Project *Orion*, according to Harold B. Finger, direc-or of its Nuclear Propulsion Office. Marshall Space Flight Center had recommended that the program be continued, ncluding some underground testing of the nuclear pulse ropulsion theory (M/R, Dec. 14, p. 12). The NASA action ollows a Dept. of Defense decision to halt funding on the ame system because of an Administration decision that such system cannot be used while the nuclear test ban treaty is n effect. In addition, NASA feels there are more urgent proj-cts on which to spend the money.

Gen. McConnell To Succeed Gen. LeMay

Gen. John Paul McConnell, who will succeed Gen. Curtis LeMay as Air Force Chief of Staff on Feb. 1, is described y his associates as equally brilliant and somewhat more rticulate. Gen. McConnell has been vice chief since last ummer. Reports that he will be more docile than Gen. LeMay in his relations with his civilian superiors are not ecessarily true—he is regarded as a man of strong opinions.

F-1 Engine Passes PFRT

NASA's F-1 engine, built by Rocketdyne, passed its Pre-iminary Flight Rating Test (PFRT) late in December. De-pite some problems with combustion instability which elayed the test, space agency officials report that develop-nent of the engine took just about the six years which was redicted when it was announced in October, 1958.

Last 50 Minuteman Silos Set for Bid

Ballistic Missile Construction Office of the Corps of Engineers has issued bid invitations for the construction of 50 *Minuteman II* silos at Malmstrom AFB, Mont. With the decision that 1,000 *Minutemen* will be enough (see p. 10), this will complete the construction program of new silos.

Expandable Tunnel Studied for MOL

Goodyear Aerospace Co. has received a contract to study an expandable tunnel for transfer of pilots from *Gemini* to the *Manned Orbiting Laboratory*. Preferred method, however, still is accomplishment of transfer through the *Gemini* heat shield.

Saturn 9 May Go Next Month

Launch of the *Saturn 9* booster and its *Pegasus* meteoroid detection satellite now is scheduled for late February or early March. The satellite—cause of a launch delay—passed its environmental tests about two weeks ago. It now has been shipped to Cape Kennedy.

NASA Budget Plateau Is Seen

Administration officials believe the NASA Fiscal '66 budget will be at about the same level as this year's approved total of $5.25 billion. While final details of the budget request still are being worked out, the range has been established at between $5.2 billion and $5.4 billion. Only major new start will be the *Voyager* spacecraft, with cost of a five-year development program estimated at $1 billion. Total NASA expenditures in the coming fiscal year will be about $5.5 billion.

INDUSTRY

Westinghouse Sets Up Undersea Service

Westinghouse Electric Corp. has set up a charter service to provide ocean-going equipment and technical personnel for undersea research and exploration. The company is offering oceanographic equipment, services and personnel for. a variety of undersea missions, including several diving submersibles and a support ship with crew. The move is part of a man-in-the-sea program being developed by the underseas division of the firm's Defense and Space Center in Baltimore.

Big Response on California Proposals

Twenty-three industry firms submitted bids for California state contracts aimed at application of the industry's advanced technology to three state problem areas. The bids are for engineering studies for developing systems of waste management, information collection and retrieval and care of the mentally and criminally ill. Bids for a fourth study, also to be for no more than $100,000, were due Dec. 31. This is for development of a plan of air, sea and surface transportation for the state.

INTERNATIONAL

USSR Space Cooperation Is Uncertain

The U.S. and the Soviet Union for the moment are at an impasse on space cooperation. No reply has been received to a letter sent Soviet negotiators concerning a space medicine agreement. Dr. Hugh L. Dryden reports he will not attend the 1965 COSPAR meeting in South America in May—when the next talks are set—unless he gets some indication the Russians have stepped back from their previous position. This called only for an American author to analyze Soviet published data on space medicine while a Russian was granted the same access to U.S. literature.

ICBM Cutback Announced

The U.S. ICBM force is being cut back under the 1966 defense budget, approved by President Johnson late last month.

The new budget, however, reduced by about $500 million from this year's figure of $49.8, authorizes development of the *Short Range Attack Missile (SRAM)*, to be carried by existing B-52's, B-58's and future Air Force bombers (M/R, Oct. 26, p. 15).

Under the budget, 200 *Minuteman* ICBM's previously programmed are being dropped, despite an urgent recommendation for approval by Gen. Curtis E. LeMay, retiring Air Force Chief of Staff.

As announced last November, all U.S. *Atlas* and *Titan I* missiles will be phased out by mid-1965, leaving only 54 liquid-fueled *Titan II* ICBM's. Thus, the ready force, now totaling about 700 *Minuteman* missiles and the 200 *Atlas* and *Titan* missiles, will shrink next summer when only the *Titan II's* and 800 of the planned *Minuteman* missiles will be in service. Two hundred *Minuteman II's* will be deployed later.

Gen. LeMay had argued that a force of 1,800 ICBM's was necessary for adequate national defense.

The Pentagon explained the cutback on two grounds: new U.S. intelligence indicating fewer Soviet ICBM's—about 200 in total—than previously estimated and thus fewer targets, and improvement in the accuracy and warhead yield and advanced re-targeting capabilities of the *Minuteman.*

The cutback apparently caused rejection of other proposals at the defense budget discussions in December. The Army was refused $200 million for construction of components of the proposed *Nike-X* anti-ICBM. A Navy request for a nuclear-powered guided missile frigate was also turned down.

GAO Probes Procurement

A new series of studies on Defense Department procurement is being conducted by the General Accounting Office at the request of the House Appropriations Committee.

Contracting procedures on electronics equipment, aircraft procurements and other "important segments" of DOD are under a major review by GAO, Comptroller General Joseph Campbell's report to the new Congress reveals. Exact cases being investigated have not been disclosed.

In the report, Campbell again attacks DOD's policy of negotiating contracts, a practice followed in 80-90% of the total dollar value of military spending, he said. He said that "our reviews continued to disclose instances of excessive negotiated prices."

Five types of overcharges resulted in these contracts, he said. They were listed as: negotiations based on erroneous cost information, negotiations based on cost information inconsistent with experienced costs, negotiations based on price proposals containing unwarranted provision for contingencies, negotiations of final prices not consistent with contract terms, and negotiation of an inappropriate type of contract. Many of these practices also occurred in subcontracting, he said.

Early Bird Launch Set

The Communications Satellite Corp. has contracted NASA to launch the first *Early Bird* communications satellite as soon after March 1 as is feasible. Under an agreement signed last month, ComSat will pay $3.5 million for the initial shot and each subsequent launch.

The launch aboard a *Thrust-Augmented Delta* is tentatively scheduled for March 2 from Cape Kennedy. The space agency will provide a backup launch in case the first *Early Bird* is not successful.

Boeing Gets Bigger Saturn Job

The Boeing Co. has been named systems integration contractor for NASA's three-stage *Saturn V* booster.

The work will be performed at the firm's launch systems branch at New Orleans under an $85-million addition to its contract as prime contractor for the booster's first stage.

The systems and engineering integration will be conducted in three major areas: the vehicle, systems documentation, and systems development breadboard facility.

On the vehicle itself, Boeing will be responsible for mechanical interface engineering, instrumentation and telemetry systems, aerodynamics and flight mechanics, flight evaluation and operation, atmospheric environmental design criteria, malfunction detection system, structural heating and environmental control system, structural dynamics, and vehicle assembly documentation.

MSFC Negotiates Contracts

NASA's Marshall Space Flight Center is beginning final negotiations with 14 firms for support contracts estimated at $68 million.

The nine cost-plus-incentive-fee awards will provide engineering, fabrication and institutional support services to six laboratories and three offices at Marshall. The contracts—primarily in support of *Saturn* and *Apollo* launch vehicle programs—will be for one year, with provisions for renewal. They are scheduled to be in effect by March 1.

The 14 companies and contracts (with estimated values) involved include: Sperry Rand Corp., final negotiations for a $13.5-million contract to support the Astrionics Laboratory; Brown Engineering Corp. and Chrysler Corp., competitive negotiations for a $16.3-million contract in support of the Propulsion and Vehicle Engineering Laboratory; Vitro Corp., final negotiations for a $6.5-million contract to support the Test Laboratory; Hayes International Corp., final negotiations for a $9-million contract to support the Manufacturing Engineering Laboratory.

Northrop Corp., final negotiations for a $4-million contract to support the Aero-Astrodynamics Laboratory; Spaco and General Dynamics/Astronautics, competitive negotiations for an $8.5-million contract to support the Quality and Reliability Assurance Laboratory; Rust Engineering Co., final negotiations for a contract to support the Facilities and Design Office.

RCA Service Co. and ITT Kellogg Communications Systems Div., competitive negotiations for a $6-million contract to support the Management Services Office; J. T. Schrimsher Co., Management Services, Inc., and Dow Chemical Co., competitive negotiations for a $4-million contract to support the Technical Services Office.

NASA Creates New Position

A new position of director of mission operations has been announced by NASA as part of a realignment within the Office of Manned Space Flight. E. E. Christensen has been named to the post, which replaces the office of deputy associate administrator for manned space flight operations.

Purpose of the reorganization—which went into effect Jan. 1—is to meet requirements imposed by concurrent *Gemini* and *Apollo* launch schedules, the agency said.

Christensen will be responsible for planning, coordinating and directing all NASA activities involving manned missions and unmanned flight tests of spacecraft configurations to be flown on manned missions. He was formerly special assistant to Dr. George E. Mueller, associate administrator for manned space flight.

Shots of the Week

A "tripleheader" at Vandenberg AFB, Calif., Dec. 22, plus NASA's orbiting of *Explorer 26* highlighted a holiday season launch schedule at the nation's missile ranges. The three Air Force shots from Vandenberg were:

- A secret satellite launched into polar orbit by a *Thor-Agena* combination.
- A launch identified as a "space probe," but believed to have been the second successful launching of a contact cesium ion engine by the Air Force. The engine used in the Dec. 22 flight, developed by Electro-Optical Systems, Inc., was about 5.5 in. across and 8 in. long.
- An *Atlas F* ICBM, one in a series of launches to determine compatibility with various payloads for space use and for re-entry purposes.

In other launches:

- *Explorer 26*, a 101-lb. satellite designed to study how high-energy radiation particles are injected into, trapped in and lost from the Van Allen radiation belts, went aloft aboard a *Delta* booster Dec. 21 from Cape Kennedy. It had an initial highly elliptical orbit with an apogee of 16,280 mi., a perigee of 190 mi. and a period of 7 hrs., 40 min.
- The *Thor-Agena* was also used Dec. 21 to launch another Air Force secret satellite from Vandenberg.
- The Navy's *Polaris A-3* scored ts 13th straight success Dec. 22 from he submerged submarine Von Steuben off Cape Kennedy.
- The 509th Strategic Missile Squadron of the 351st Strategic Missile Wing, Whiteman AFB, Mo., carried out a successful operational aunch of a *Minuteman* ICBM (number 77) from Vandenberg Dec. 18.
- Seven meteorological probe vehicles were launched Dec. 16 and 17 rom the Pacific Missile Range. The Navy said the launches included the *Denpro II* and *III*, and the first test of the *Frangible Arcas*. The *Denpro* s a Navy-designed probe including a *Sparrow II* missile booster and an *Arcas* second stage. The *Frangible Arcas* is built for the AF Cambridge Research Laboratory by Atlantic Research Corp. The probes were aunched from San Nicolas Island.

S-BAND TELEMETRY
AUTOMATIC TRACKING SYSTEM,
the ideal Missile or Weapons Range instrument for
off-the-pad tracking,
target acquisition,
and back-up for
larger primary tracking systems.

This compact, high-performance system offers unusual economy, reliability proven in exhaustive tests and actual range operation, and quick delivery (90 days ARO). It is suitable for ground, mobile, or shipboard installation, and neatly packs these features:

- Antenna: 8 ft. dia., conscan (monopulse also available)
- Frequency: 2150 to 2350 Mc, gain 28 db min.
- Rated Velocity: 36°/sec.
- Rated Acceleration: 32°/sec.^{2}
- Accuracy: 0.1° at max. vel.
- Tracking to 88° El. with secant gain correction.
- All solid-state servos.
- Selectable servo response.
- Multi-mode operation.
- Position indicators and calibrated error meters.
- Carrier threshold indicator.
- Meets MIL-I-26600, RFI.
- Withstands severe MIL spec environments.

This system is complete, including receiver and preamplifier. A full range of accessories is available. Write for full information.

S·A SCIENTIFIC-ATLANTA, INC.
BOX 13654, ATLANTA, GEORGIA 30324, TEL. 404-938-2930
TWX 404-938-1322 WUX CABLE SCIATLA

Circle No. 6 on Subscriber Service Card

No recommendations made . . .

Study Aids Case for Nike-X

by James Trainor

PRIMACY of offense over defense in strategic warfare—a shibboleth long-accepted by defense planners—has been called into question by the *Nike-X* threat analysis study.

Several other "truisms"—such as the "destabilizing" effect of a ballistic missile defense (BMD) system on deterrent posture, the severity of the "Nth country" problem and the cost of penetrating an anti-missile missile defensive system—have been found to be either invalid or highly dependent on the scenario under which strategic nuclear war occurs.

In the making since July, 1963, the highly classified, voluminous threat analysis has been completed and submitted to Secretary of Defense Robert S. McNamara. Presenting no recommendations, the analysis does provide the arithmetic underpinning upon which a decision to deploy or not to deploy *Nike-X* can be based.

The trade-off studies involved in deploying a ballistic missile defense system are far from complete, however. Detailed studies of levels of deployment, protection of command and control centers vs. protection of urban centers, protection of critical industry, the rate of recovery of the nation in relation to the protection—and the survivability—of the civilian industrial base are but a few of the intricate questions still to be probed.

- **Study's scope**—These analyses will not be conducted on the "crash" basis that the threat analysis study involved, nor will they be as centralized as was the basic study. The threat analysis study covered more than a year of intensive effort and involved more than 200 professionals full-time.

The Hudson Institute pulled together inputs from a wide range of industrial and military sources. A *Nike-X* threat analysis office was created within the Army staff and was headed by Maj. Gen. Austin W. Betts.

Stanford Research Institute has been retained by the Army to conduct further trade-off studies, but the special character of the threat analysis office is also to disappear, with future studies and analyses performed by elements of the Army staff, particularly the Deputy Chief of Staff for Operations.

- **Offense vs. defense**—Almost from the inception of the *Nike-Zeus* program, its critics have claimed that, given the character of modern strategic missiles, the defense would never be able to catch up to the offense. For a modest investment, the argument ran, the offense would be able to overcome any defensive system with ever more sophisticated penetration aids.

On the basis of the threat analysis study, however, the offense and defense "are very much closer to a standoff now," according to a Defense official, and the cost of one overcoming an advantage of the other are "in the general ball park of equivalence."

"Except for a few people on the outside of the problem," this official contends, "all of the people who have really studied the problem, including organizations such as the Rand Corp. and the Weapons System Evaluation Group (DOD), agree that ballistic missile defense is a useful contribution to a damage-limiting strategy."

The usefulness of ballistic missile defense is extremely sensitive to the scenario under which a strategic nuclear war takes place, this official points out. If such a conflict occurs as a result of an ever-deepening international crisis in which both sides steadily increase their readiness postures, the value of BMD is less than if a sudden attack were mounted against this country by the Soviets.

In the first instance, the U.S. could receive enough warning of Soviet intentions to strike before the Soviet missiles were launched. Under these conditions, it makes more sense to invest in such damage-limiting weapons as *Minuteman* ICBM's and anti-submarine weapons.

Also, the official says, if the Soviets are incapable of launching all their ICBM's in one salvo, offensive missiles would be effective in destroying these missiles before they could be launched. BMD, even in this scenario, would still contribute to damage-limitation by countering at least partially those missiles which were launched against the U.S.

A defensive system would be the major means of blunting a surprise attack. The system would not be able to counter all the ICBM warheads launched against the U.S., but it would kill a percentage of them.

This is the important point: a BMD system "can be defeated in part, not in total." And the extent to which it is not defeated could determine the ability of the nation not only to survive but to recover from a nuclear war.

Therefore, the proper mix of damage-limiting forces depends on the magnitude of the threat and the postulated scenario under which war occurs.

- **BMD de-stabilizes nothing**—"There isn't enough defense in the world to protect everyone. Therefore, the destabilizing argument is just not valid," is the way one Defense official disposes of the argument that to deploy a BMD system would upset the mutual deterrence brought into being by the possession by both major powers of the means of destroying each other's societies. There will always be deterrence, even with a ballistic missile defense system, he feels, because it is just not feasible to protect all the population.

On the subject of the "Nth country" problem—the proliferation of nuclear weapons and their means of delivery by smaller, and presumably less responsible, countries—it now appearas that this would not be as serious as first supposed. "Take the case of the mad Cuban with one missile. He is not likely to waste that missile on Podunk but is more likely to concentrate on New York or Washington—the prestige, high-density target." Therefore, the BMD deployment problem would be easier, with the defensive system concentrated around these centers.

If this "mad Cuban" did avoid the prestige target because of his awareness of the defenses surrounding it, BMD still has paid off by denying him an attack on the high-density centers. ■

Program opposition aired . . .

NASA Approves Voyager Development

by Hal Taylor

TOP NASA OFFICIALS have approved development of the *Voyager* spacecraft for Mars exploration missions in 1971 and 1973.

A request for proposals for preliminary design of the spacecraft bus will be issued by the space agency in one to two weeks. Two to four contractors will be selected for the three-month contracts.

Phase I procurement plan then calls for one or two of the firms to be given a follow-on systems design contract. Phase II selection of the prime contractor for the spacecraft is expected in the spring of 1966. The spacecraft portion of the program will be managed by the Jet Propulsion Laboratory.

The second part of the *Voyager* program—procurement of a landing capsule—will also be started this year, but a decision on an exact date has not yet been made.

- **Opposition voiced**—Meanwhile, a biologist at a meeting of the American Association for the Advancement of Science in Montreal, Canada, attacked the whole project, declaring that the expenditure of more than a billion dollars is not necessary.

Prof. Barry Commonor said that "life on Mars is impossible and there is no good reason to design instruments to seek it."

Information which could cast a shadow of doubt over the *Voyager* program, he told the meeting, has never been placed before Congress or the nation.

Commonor, chairman of the botany department of Washington University, St. Louis, said that as a new member of the governing board of the American Institute of Biological Sciences, he plans to bring all the facts about the Mars project out into the open.

He attacked a recent report of the Space Sciences Board of the National Academy of Sciences, which declared that Mars exploration should be the primary space goal in the 1970's.

"Current measurements show Mars has no liquid water. If liquid water is lacking, there is no reasonable basis for the expectation of life. . . ."

- **Alternate study proposed**—Rather than searching for life on Mars, as *Voyager* is designed to do, Commonor said that the spacecraft should carry instruments capable of making a geochemical analysis of the Martian surface. He told the meeting that technicians know how to build such instruments, but not instruments capable of detecting life on a planet that cannot support the kind of life that exists on Earth.

He accused scientists who testify before Congress of not attaching sufficient importance to the anti-life theory.

"I have searched in vain for discussion of such alternatives in the relevant statements of NASA and the Space Sciences Board. It is also singularly absent from much of the scientists' testimony before Congress."

Despite the opposition of Commonor—the first voice raised against the *Voyager* program—the space agency said it is going ahead with its plans for the project.

With most of the details of the spacecraft bus procurement ironed out, officials of the Office of Space Science and Applications are now turning their attention to the problems associated with selecting a firm to develop the capsule that will actually land on the Mars surface and the scheduling and management of the *Saturn IB/Centaur* launch vehicle.

- **Langley good bet**—One of the major problems in the landing capsule portion of the program is the selection of the NASA field installation that will have management responsibility for it.

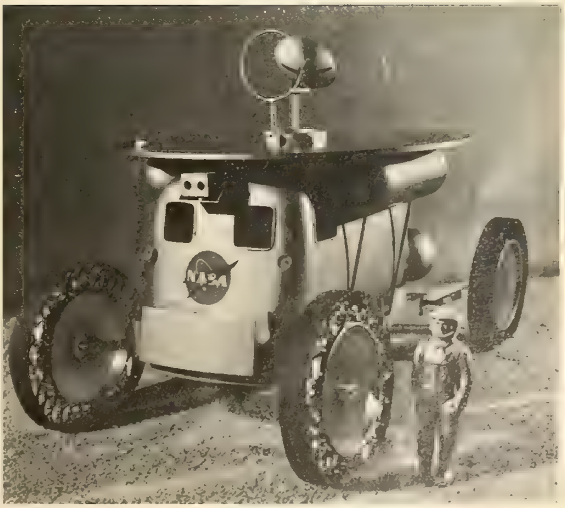
Four centers are in contention, the Ames Research Center, Jet Propulsion Laboratory, Langley Research Center and the Goddard Space Flight Center. According to informed sources, the center most likely to win the management role is Langley.

Another pending decision that is delaying part of the program is the question of test flights of the launch vehicle and spacecraft systems in 1969. Space science officials want to make two such flights and tentative plans now call for the flights to be made. This could be changed if future budgets are cut either by the Administration or Congress.

In the launch vehicle area, a decision is expected in the near future on the field center and program office at NASA headquarters which will be responsible for the program. Contending for the role are the Lewis Research Center and the Marshall Space Flight Center, as well as the Office of Manned Space Flight and the Office of Space Sciences and Applications. The best bet appears to be the Office of Space Sciences and Applications and Marshall together.

The major change involved in the program is the development of a shroud for the vehicle as well as strengthening the payload ring in the *Centaur* in order to support the heavy *Voyager* weight. ■

MOLAB Model Shown



THIS IS a scale model of a mobile lunar laboratory designed by The Bendix Corp.'s Systems Div., Ann Arbor, Mich., for NASA as part of a study on how to support two astronauts for two weeks when they land on the Moon. It would serve as a "mobile home" and lab while they collected materials for analysis.

Senate May Scrutinize NASA Patent Waiving

Members of both houses hit clause allowing agency to waive government rights to inventions growing out of R&D contracts; a look at early plans of committees

A SENATE Small Business subcommittee has been asked to examine NASA's patent waiver policy, which critics charge is depriving the government of inventions developed under government funds.

Complaints of both Senate and House members have been made know to NASA Administrator James E. Webb, in an exchange of letters during the adjournment of Congress. The issue was precipitated by the publication in the *Federal Register* of the space agency's latest patent regulations, which became effective Sept. 28.

Leader of the House objectors is William F. Ryan (D-N.Y.), member of the House Science and Astronautics Committee. Ryan, who objected to patent waiver regulations which NASA proposed in January, 1963, said that the new regulations are "even more objectionable" and asked for a full explanation of why NASA circumvented the Congress on the new policy.

Sen. Lee Metcalf (D.-Mont.), one of the original House Space Committee members who worked on the patent problems in drawing up the National Space Act of 1958, echoed Ryan's feelings. In a letter to Webb, Metcalf said that "the present patent regulations . . . are not in accordance with the legislative intent of that Act nor of a majority of the members of Congress."

Crux of the argument is the clause which allows NASA to waive the government's rights to patent inventions developed under NASA research and development contracts. Sen. Wayne Morse (D-Ore.), one of the most outspoken critics of the policy, estimated that the new regulations "have the effect of transferring the results of this year's $4.4-billion taxpayer-financed NASA research and development to the sole benefit of a limited number of large corporations, since only about 11% of NASA's R&D funds go to small business." Morse has indicated that he will introduce legislation "with appropriate sanctions, and with retroactive effects, to prevent NASA disposition of patent rights without appropriate compensation."

• **Language killed**—Metcalf told MISSILES AND ROCKETS that when the patent question for NASA was originally considered, he realized that inventions might result which would be based upon the experience and background of the contractors, especially those who had been in the aviation field. For this reason, he said, members of the House group included language which would allow NASA to waive patent rights at the request of the contractor, at the termination of the contract. However, this precise language was deleted in the final conference version.

The new regulations just published, he said, provide for the Administrator to waive the rights in advance of the contract. Unless it has been determined that the invention is due to the contractor's own experience and determination, he said, "the government should have the right to license this or any other contractor to develop the invention so that the consumer gets the full spinoff benefit."

In reply to Congressional critics, Webb said that he felt that the revised regulations follow the guidelines set down by President John F. Kennedy's statement of Oct. 10, 1963, defining when the public interest will be served by waiver of rights to inventions. Since the regulations also are authorized by the language of the Space Act, he said, the effective date of the regulations could not be postponed, as Ryan had requested.

The Senate group asked to consider the controversy is the Monopolies Subcommittee of the Small Business Committee, headed by Sen. Russell B. Long (D-La.). A meeting will be held by the subcommittee shortly after Congress reconvenes this week to decide whether to take the matter up.

• **Slow road ahead**—In general terms, Congress is expected to take longer in the authorizing process this year because of the many new members on the various committees. The House Science and Astronautics committee, for instance, will have to fill about five vacancies, and the House Armed Services about 11, if the committees are kept to the same level in membership.

Most of the committees plan to begin hearings around the end of January or February first, since the first few weeks will be taken up with organizing the new Congress and making committee assignments.

Here is the outlook for several key groups:

• **Senate Space Committee**—According to Sen. Clinton P. Anderson, (D-N.M.), first meeting of the committee will be held in the latter part of January. The committee will be watching NASA and DOD in their study of means to cooperate in the *Manned Orbiting Laboratory (MOL)* and *Apollo-X* programs, an agreement which was reached after a suggestion by Anderson that the two programs be combined. However, neither program is being dropped.

Booster hearings, which were scheduled and postponed last year, may be taken up this year, although this is one of the matters the committee must decide in its initial sessions.

• **House Space Committee**—Besides the manned space station programs, the committee is expected to look at some of the programs which have had difficulties in the past. Rep. Joseph Karth (D-Minn.) told M/R that his subcommittee will take a hard look at *Centaur*, with the hope that its problems have been worked out. He expressed the feeling that the longer the program slips, the greater the possibility that payloads will have to be rescheduled to other vehicles. "If it misses another program," he said, "then *Centaur* may have outlived its usefulness." Pace of the scientific programs will also be examined, he said. Karth expressed a hope that the FY 1966 budget would reflect "a realistic Mars program."

• **House Armed Services**—This committee will have a new chairman, expected to be top-ranking Democrat Mendel Rivers (S.C.). Topics expected to be of especial concern will be *MOL*, *Nike-Zeus/Nike-X*, and the manned bomber program. The Special Investigations subcommittee also has announced that it will hold hearings on activities of the Aerospace Corp. ■

DOD approval needed . . .

Wyman-Gordon Set to Build World's Second Biggest Forging Press

200,000-ton unit would cost $56.8 million to put in operation; Soviets designing even bigger press; wide advantages foreseen

by John F. Judge

North Grafton, Mass.—Preliminary plans for construction and installation of the second biggest forging press in the world—a closed-die press with a 200,000-ton rating—are now complete.

The program waits only a go-ahead signal from the Dept. of Defense.

Wyman-Gordon Co. has completed preliminary designs, cost analyses and installation specifications in Air Force Plant 63, a facility already housing a 50,000-ton forging press and operated by the firm for the Air Force.

The current press is one of the largest closed-die forging presses in the country and has been instrumental in various aircraft, missile and space programs over the past decade.

The Soviets some time ago recognized the need for heavy forging presses; they have been operating a 77,000-ton press facility for about two years. A 220,000-ton press is currently being engineered and designed in Russia.

Total cost of the U.S. effort to put a 200-KT press in operation is $56.8 million, with $34.5 million allotted to the press itself and the rest for associated equipment. The program calls for operational use some 33 months from the initial go-ahead.

Press design incorporates several innovations based on its size and the experience gained in designing, building and using the 50,000-ton unit.

Initial response from the aerospace industry has been excellent. Many firms and highly competent individuals are joining Wyman-Gordon and the Air Force in urging a start for the program.

DOD has adopted a wait-and-see attitude, since much of the technology in forging at such immense pressures is unknown.

There are, of course, other metal forming methods—such as explosive forming, ring rolling and molecular forming. But these methods are still in their early stages of development. In the opinion of most designers, most load-bearing components in aircraft systems will be forged.

- **Press family**—The 200-KT would join a family of existing presses at the Wyman-Gordon facility and would operate in conjunction with the others. For instance, a blocker forging reaching the limits of the 50,000-ton press could be precision-finished on the 200-KT unit.

The 50,000-ton press itself represented a major step forward in the evolution of large forging presses. Wyman-Gordon specialists say this unit has proven the design concept and its years of relatively trouble-free operation backs this up (M/R, Feb. 1, 1960, p. 19).

Current requirements and years of experience indicate to Wyman-Gordon experts that presses of a similar design but with heavier ratings would serve the industry well—provided the press beds would be made smaller rather than larger, concentrating the total pressure on a smaller area.

The 200-KT press can also handle extrusions beyond the current state of the art.

- **200-KT details**—The press was designed by Alexander Zeitlin, vice president of Barogenics, Inc. Zeitlin was instrumental in design and construction of both the 35,000- and 50,000-ton presses at Air Force Plant 63.

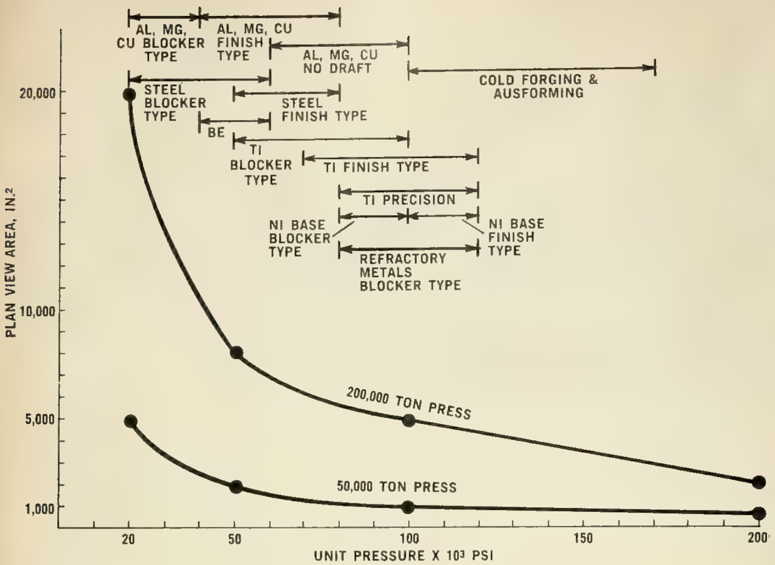
The rated capacity of the big press is 200,000 tons, with a total pull-back system of 28,000 tons. Its stripping capacity is 2,000 tons.

The main system stroke is 12 ft., with each side cylinder having a stroke of 5 ft. The daylight between bolster

FORGING SIZE RANGES FOR 50,000 TON AND 200,000 TON PRESSES

MATERIAL	TYPE OF FORGING	AVERAGE PRESSURE REQUIRED (Lbs. per Sq. In.)	MAXIMUM PLAN VIEW AREA 50,000 Ton Press (Square Inches)	MAXIMUM PLAN VIEW AREA 200,000 Ton Press (Square Inches)
ALUMINUM	Blocker	20,000 to 40,000	5,000	20,000
MAGNESIUM	Finish	40,000 to 80,000	2,500	10,000
COPPER	Precision	60,000 to 100,000	1,600	6,400
STEEL	Blocker	20,000 to 60,000	3,000	12,000
	Finish	50,000 to 80,000	1,600	6,400
TITANIUM	Blocker	50,000 to 100,000	2,000	8,000
	Finish	70,000 to 120,000	1,400	5,600
NICKEL BASE ALLOYS	Blocker	80,000	1,250	5,000
	Finish	120,000	830	3,320
REFRACTORY AND NUCLEAR METALS	Blocker	80,000 to 120,000	1,250	5,000
BERYLLIUM	Finish	40,000 to 60,000	2,500	10,000

THIS COMPARISON between abilities of two presses to handle various metals now in use covers only approximations. There are other factors in any forging.



APPROXIMATE PLAN view areas of various forging designs are listed, assuming present state of the art in die systems and lubrication.

WYMAN-GORDON'S 18,000-ton press in operation at North Grafton.

plates is 18 ft. The bed size is 26 ft. from front to back and 18 ft. from left to right—giving a total bed area of 468 sq. ft.

The press will tower 83 ft. above the floor, with another 82 ft. of structure below the floor. The frame system pressing speed is 120 in./min., with an advance speed of 360 in./min. and a return speed of 360 in./min.

The die holding system employs hydraulic clamps. Maximum hydraulic system pressure in the press is rated at 7,100 psi.

• **Proposed applications**—The tonnage of the 200-KT press with a stretch-wrap insert would make it possible to form plate stock as a preform for the forging of window frames or stiffeners for *Apollo*-type spacecraft construction.

Large structural components for reentry vehicles could be forged in high-temperature and refractory materials. These would have thinner webs and panels and greater mechanical property levels than are available by other forming methods.

In the deep submergence and undersea area, certain structural members of submarines such as hull plates, hemispherical or elliptical end caps would be greatly strengthened through the incorporation of integral stiffening. No capability for such production exists today.

In solid-rocket motor cases, the 200-KT press would make possible a one-piece forging for the 120-in. motor case head to replace the five-boss and attach-ring all-welded structure now being used.

The proposed press could turn out one-piece heads for the 156-in.-dia. motor cases instead of the skull-cap and gore-welded approach now being used. The press could reduce the number of welded pieces in the 260-in. motor head from 18 to five—with a corresponding elimination of much of the welding.

With the size cylinder adaptation of the 200-KT press, full nozzle sections such as those for the 120-in. solid booster could be forged in one piece. Throat liners for larger solid rockets could be forged in a single piece, in the maraging steel alloys.

Big press proponents cite a number of direct advantages in the development and production of hardware for aircraft, aerospace craft, propulsion equipment, ordnance, deep submergence and other defense needs.

The first and obvious benefit is the ability to forge larger component sizes as various vehicles increase in size. Small parts can be combined into single-unit forgings and the larger parts can be produced to tighter designs.

Structural integrity is enhanced by the forging process. This characteristic would go hand-in-glove with the size advantages of the 200-KT press.

Larger forgings would also help cut the weight and bulk in the final structure design by reducing the number of joints and splices and substituting a single large forging for an assembly built up from a number of smaller ones.

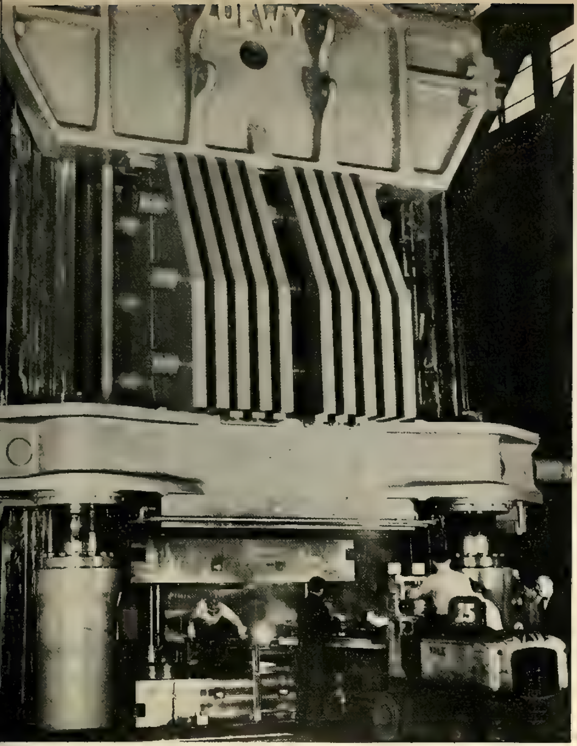
The forging process imparts extensive, controlled working to the metal, and this enhances reliability of the component.

Big press proponents also cite cost reductions, material conservation and a reduction of machining as definite advantages. However, these points are heavily dependent on the component design and the choice of material.

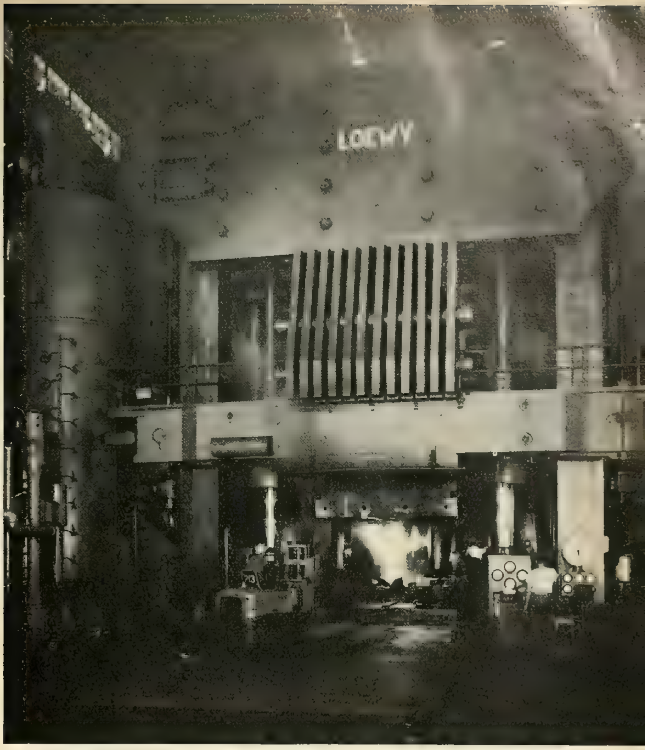
The newer materials are more difficult to work and the larger press can significantly improve the state of the art in this area.

• **Background critical**—One of the strongest arguments for implementing the program is the experience with the 18,000-ton, 35,000-ton and 50,000-ton forging presses at Air Force Plant 63.

Once developed and in operation, the presses proved to be invaluable in many of the major aircraft programs of the past two decades. For instance, the 35,000-ton press turned out wing spars for the Convair F-102 aircraft which were 10.5 ft. long, 18 in. wide and



35,000-TON closed-die hydraulic press in operation at Wyman-Gordon since March, 1955, weighs 7,180 tons.



50,000-TON closed-die hydraulic forging press is turning out components for every major U.S. missile/space program.

had webs 3/16 in. thick.

Four of these were used in each aircraft, replacing 272 pieces and 3,200 rivets—for a total weight saving of 100 lbs. per plane.

Aircraft and missile designers have shown a tendency to use larger forgings to the fullest extent as each press and its characteristics became more familiar.

Forging experts at Wyman-Gordon feel the same thing will hold for the 200-KT press. As one man put it, "first they want a small piece forged from some high-strength alloy—and we do it successfully. Next comes a request for a larger component, say a shaft. Then they move to the next size component in the assembly until the whole thing becomes a series of forged subsections."

The material mix has drastically changed over the same time period. The percentage of aluminum and magnesium is dropping while use of the high-strength steels, titanium and high-temperature alloy has increased. The big press would be a definite help in the efficient application of these materials in both current and proposed designs.

In their analysis, the large press proponents cite a myriad of parts for both aircraft and rocket assemblies. In all of these instances the various system designers have shown willingness to use very large forged parts in both current and planned programs.

- **Review conclusions**—The whole concept of the 200-KT press has been examined in detail by an *ad hoc* committee formed by the Materials Advisory Board of the National Academy of Sciences at the request of the Air Force Materials Laboratory, Manufacturing Technology Division.

The review by the committee pointed out several problem areas in the 200-KT program. There is, of course, a substantial area of argument in the cost and machining reduction areas—especially when these are cited as major advantages of the 200-KT press. This is a decision area since the question cannot resolve itself merely through weighing both arguments.

Although many different components are cited as examples in both arguments, it is clear that no one area of technology has enough requirements to support the development of a 200-KT press by itself.

In addition, the single-source aspect of the program presents a problem, despite the fact that anti-single source arguments in general are slowly losing their effectiveness. It is still a significant element in the consideration of the 200-KT press program.

Die design, cost and development is a critical factor in the 200-KT press program but Wyman-Gordon specialists do not consider it too difficult. There are unknowns, of course, since a forging press of this size exerts pressures considerably higher than anything yet experienced in the forging-press art.

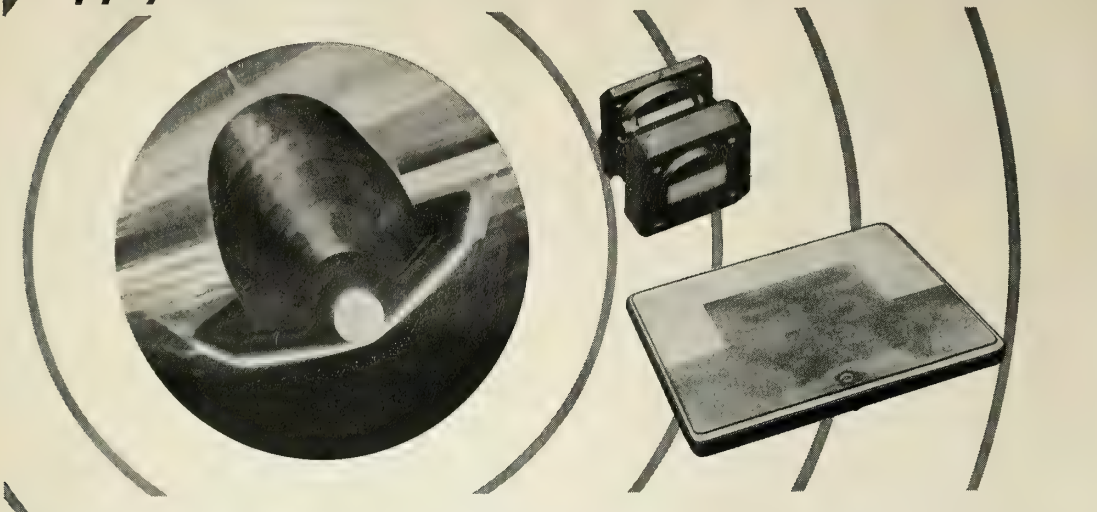
- **Welding gains**—There is a discernible trend in the aircraft and space industry toward welding primary structures. This trend is, by its nature, very slow and is spurred mainly by the non-availability of any other fabrication approach to large, load-bearing components. Thus the trend works against the implementing of a very large forging press program.

All of the man-rated rockets are primarily welded structures. This is being used as a reason for delaying a big press program—at least for its rocket part potential. One point here is that the operational life of these man-rated rockets is counted in minutes or even seconds and does not involve cyclic use over a long period of time—a characteristic of aircraft.

The next generation of large boosters may have re-usability or, at least, recoverability as an essential element. This may place a burden on the all-welded primary structure trend and necessitate forgings in key load-bearing applications.

It is not an established fact that the next booster program will definitely mean larger components—there may very well be a reduction in size. ■

Employment opportunities for those who would apply electronics as an interdisciplinary science



SIGNAL PROPAGATION AT 1900°

The interrelationship of function, environment and design has no greater example than that of the space antenna. Here, exposed to extreme pressures, temperatures, and electromagnetic interference, reliability and stable performance are essential.

During flights of the USAF Research and Technology Division's ASSET glide reentry research spacecraft, telemetry was radiated through reentry plasma by a McDonnell Electronic Equipment Division (EED) designed and built high temperature X-band antenna. Another EED antenna on the high temperature craft, a VHF cavity backed U-slot survived the reentry heating without damage and began VHF radiation as soon as the plasma sheath was left behind.

In programs such as this, McDonnell Electronic Equipment Division engineers are demonstrating the effectiveness of their approach to the application of electronics as an interdisciplinary science. The hostility of the space environment places severe tests on electronic equipment and systems. Weight and size restrictions remain paramount while resistance to space radiation, g-loads and temperature variations become more important as the missions grow more complex.

While the application of electronics in the space environment is a major program at McDonnell, systems and equipment under active development virtually blanket the environmental spectrums of earth, sea, and atmosphere as well as space. Engineers enjoy the advantage of clearly defined and supported corporate objectives that lead projects out of the laboratories and into application. Well-equipped engineering laboratories and manufacturing facilities combined with continued corporate reinvestment aimed at technological growth provide the environment necessary for professional growth. **Current requirements exist for electronic engineers capable of systems planning, simulation and integration for aircraft, spacecraft and missiles as well as advanced technological contributions in the fields of plasma physics, information theory, laser technology and microwave techniques. Openings at all levels exist in the fields of Guidance & Control, Space Communications, Radar & Electro-Optics, Plasma Physics, Reconnaissance Sensors, ECM & Electronic Warfare, and System Integration & Testing.**

MCDONNELL

Mail This Form To: McDonnell Employment, Dept. PP-14, Box 516, St. Louis, Mo., 63166

Name ______________________ Home Address ______________________

City & State ______________________ Phone ____________ Age ______

Education: BS ________ MS ________ PhD ________ Major Field: ______________
Date Date Date

Primary Experience Area: ______________________ Present Position: ______________________

______________________ Number of Years ________ I would like to receive application form ☐

An Equal Opportunity Employer

Circle No. 7 on Subscriber Service Card

Technical Countdown

PROPULSION

Steam for Space

The Atomic Energy Commission has started an in-house study to look into using steam as the working fluid for space power plants for electric propulsion. The region of interest is one megawatt electrical output. If the conclusions of the study are favorable, then it will reverse the AEC's earlier position with respect to steam and bolster an earlier Air Force report on the advantages of this working fluid (M/R, April 27, 1964, p. 24).

ELECTRONICS

Large MM-wave Dish Built by British

A 15-ft.-dia. dish antenna, designed by the Marconi Co. for the Queen Mary College of London University, will be operated as a radio telescope at wavelengths of about one millimeter—possible the largest ever built to operate at such short wavelengths. The dish employs an epoxy-resins structure reinforced with glass fibers and has a zinc-sprayed surface. The paraboloid has a measured surface accuracy of within 0.005 in. (RMS) of its theoretical geometric curve. Installed at Costie Green, near Brentwood, Essex, it was used for the first time Dec. 18 to view the lunar eclipse.

Sperry Gyro Wins Big Marshall Contract . . .

The Space Support Division of Sperry Gyroscope Co. has been selected by Marshall Space Flight Center to staff and manage its astrionics laboratory at Huntsville, Ala. The contract, which could total $13.5 million, will require about 1,000 Sperry technical and administrative personnel. The lab deals primarily with development of supporting electronic subsystems for MSFC-developed multi-stage launch vehicles.

. . . and Sperry-Univac Wins Another

The digital data processors to be used on the ground to support the *Apollo* Manned Space Flight Network will be provided by Univac Division of Sperry Rand. Winner over four other major computer manufacturers, Univac will build 10 systems for installation aboard three tracking ships and at NASA ground-tracking and training centers under an estimated $4.5-million contract. Developed for real-time use, the processors will handle PCM telemetry data associated with spacecraft operation and flight conditions and biomedical data from the astronauts.

Transfer-Molded Transistor Perfected

The first high-frequency, high-power transistor to be encapsulated through transfer molding techniques is being produced by TRW Semiconductors Inc., a subsidiary of Thompson Ramo Wooldridge Inc. The encapsulation technique is based on a method of molding a cap around an exposed ceramic heat sink using a special silicone molding compound developed by Dow Corning Corp. The molding process allows encapsulation of the device in a smaller package than its metal counterpart but with better performance. Total dissipation at case temperature of 25° C is 20 watts. The thermal resistance (junction to case) is 8.75 C/w.

SPACE MEDICINE

Underwater Zero-G Studied

Boeing's bioastronautics section in the Aero-Space Division has constructed an underwater laboratory to evaluate movements and exercise in simulated weightlessness. The subjects wear pressurized spacesuits filled with enough water to make the two neutrally buoyant. They then attempt to enter hatches and use other equipment being evaluated for space station design.

Unique Urine Collector Developed

Lockheed Missiles and Space Company has developed a unique urine collector for space station use, which operates independently of gravity and can be integrated with other prototype life-support equipment designed for Lockheed's *MOL* effort. The unit has safeguards against spillage, and does not operate on the space station power supply. It operates by accepting liquid through a vacuum-sealed orifice, which then flows through a valve into a contracted bladder. This valve is shut off, and a second one below it is opened to permit liquid to flow through a connecting hose into a closed loop reclamation urine still. By low-pressure boiling at roughly 85°F, the water is reclaimed, and the residue stored for disposal.

ADVANCED MATERIALS

Liners Being Developed for Glass Tanks

Liners for glass fiber filament-wound cryogenic tanks will be designed and developed under a NASA contract to the Structural Materials Div. at Aerojet-General's Von Karman Center. The permeability characteristics of filament-wound tanks at cryogenic temperatures are such that significant leakage will occur unless the tanks are lined. Normal liners materials do not strain as much as the filament-wound composite when operating at efficient stress levels. The two types of liner material under study are polymer films (Mylar and Kel-F) and metal foils. The liners will use corrugations and pleats to match the strain characteristics of the composite tanks.

Subliming Nozzles Delivered by Emerson

Three test rocket nozzles designed to maintain their geometric configuration over extended firings have been delivered to NASA's Lewis Research Center by Emerson Electric's Electronics and Space Division. The nozzles make use of the self-regulated transpiration of sublimate gases through a porous throat liner of high thermal stability to restrict liner temperatures. The endothermic dissociation of the sublimate gases within the heat-exchanging porous liner and boundary layer further acts as a thermal barrier against fuel combustion products. Each of the nozzles delivered has a throat diameter of 7.8 in.

Plasma Torches Simulate Stellar Spectrum

Plasma torches, designed and built by scientists at UCLA, are providing laboratory sources capable of simulating the stellar emissions of the hottest known stars. The devices use an extremely hot, pure plasma that can be precisely modulated and whose composition can be varied widely. Present models have a design capability of 70,000° F and other devices in the testing phases are believed capable of continuous plasma generation at one atmosphere pressure up to 180,000° F. The devices use radio frequency inductive heating to concentrate a large amount of energy in a gas with a volume of about one liter. The torches are being developed under the direction of Nobel Prize-winner Dr. Willard F. Libby and the program is sponsored by the Air Force Office of Scientific Research, Office of Aerospace Research, through the AFOSR Directorate of Chemical Sciences.

Navy Sees Promise in Infrared Thermography for Solid Case Checking

Tests on Polaris A-3 cases lead to hope that technique can be used as standard tool; it would supplement X-ray

by William S. Beller

QUIETLY EVALUATING a new application of a modern means of non-destructive testing, the Navy is "highly optimistic" about infrared thermography for checking out solid-rocket motor cases.

This is only one application of a technique that companies are considering using, on a production-line basis, to help in quality assurance of products including printed-circuit boards, jet engine and helicopter blades, and consumer items such as truck and refrigerator panels.

The Navy's interest in IR thermography stems from associated tests the service has been running for the past six months on the *Polaris A-3* motor case at the Naval Weapons Station, Concord, Calif.

"We want to use the (IR thermograph) method as a standard inspection tool either on a production line or for lot inspection, or both," Frank Hund, technical director of the station's Quality Evaluation Laboratory, told MISSILES AND ROCKETS.

Even though the hope is there, the Navy still has about a year to go in a two-year program to see what IR thermography has to offer. The service is now analyzing and correlating the data it has gathered. "We know that IR thermography uncovers conditions that other methods do not," said Hund. "We want to know precisely what these conditions are—and that is the reason for our continued study."

Hund also said that a considerable advance would be made in non-destructive testing if IR thermography could be used in quality control of such electronic components as microelectronic modules. He commented that today there is no known method to non-destructively test such modules.

- **Areas of use**—For rocket motor cases, IR thermography can be used to pinpoint voids caused by defects such as faulty bonds, delaminations and any other defects that give rise to discernible thermal discontinuities.

Such discontinuities, in fact, play a part in diagnosis of certain medical diseases. Cameras made for this purpose by Barnes Engineering Co., Stamford, Conn., gave rise several years ago to a Navy request that the company look into modifying the system for *Polaris* work. Meetings between experts from Barnes and the Navy resulted in the present system.

Barnes Engineering Co.'s earliest thermographs—dating back to 1954—were used chiefly in studies of military targets and their backgrounds, where it was necessary to focus upon fairly large objects at ranges from three feet to infinity. However, the industrial and medical field required an optical system whose resolving power would image the details of much smaller targets. Barnes says it has met these needs by close-up optics, designed to produce a "most perfect" focus at short working distances.

Deleterious conditions of interest in a solid-rocket case are delaminations and unbonds, voids, undesired inclusions and cracks—particularly in the regions between the case and the liner, between the liner and propellant, and between the layers of a filament-wound case.

One advantage of IR thermography is that it can with relative ease discover many of these conditions. Moreover, IR thermography can do a job quickly: a target of any size can be scanned and recorded in six minutes.

- **A simple method**—The entire solid-propellant rocket motor case is carried into a warming room and brought to a few degrees above ambient temperature. Upon removal from the room, the case immediately begins to cool; the cooling process takes place by the loss of heat from the surface, both by radiation and convection. Thus the heat stored in the interior of the object is continually flowing outward.

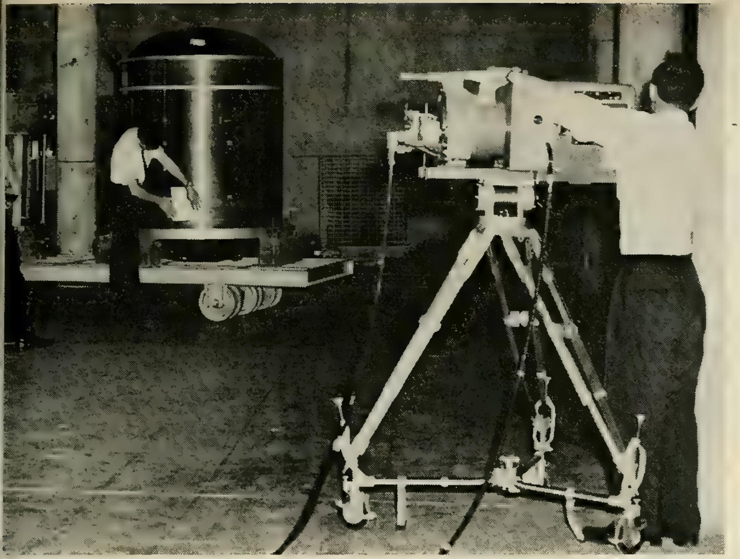
In a cylindrical engine, this flow is likely to be radially symmetrical; if there is any inhomogeneity the flow will be correspondingly impeded. This might be caused by a lack of bond between the liner and the propellant; in the surface region above this a cool spot will be created. The Barnes device measures surface temperatures and thereby discovers such spots.

The camera system contains an IR sensor—that is, a radiometer—which scans the surface of the target by a mechanical means employing mirrors, "It works for all the world like a 1928 TV set with an infrared sensor," said John R. Yoder, chief developer of the camera and manager of Barnes' Thermograph Test Service. He explained that the IR picture is reconstituted and laid down on Polaroid film for convenience.

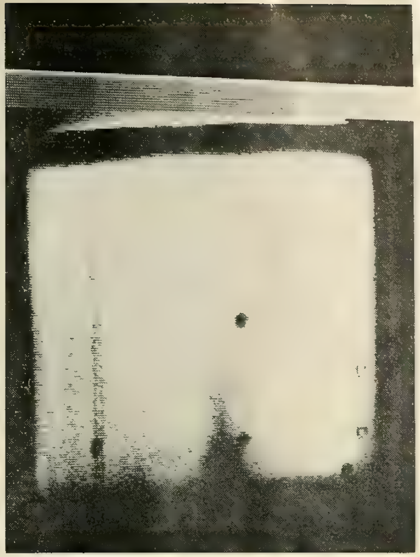
He pointed out that this is one of the advantages the method has over X-ray analysis: it is unnecessary to use a film the same size as the object under test. In fact, for IR thermography, there is no limit to the size of the object that can be tested—the camera is simply moved farther away from its target. The loss would be in thermal resolution.

Yoder emphasized, however, that IR thermography can only supplement, not replace, the X-ray method of non-destructive testing. He came back to this point several times during the M/R interview.

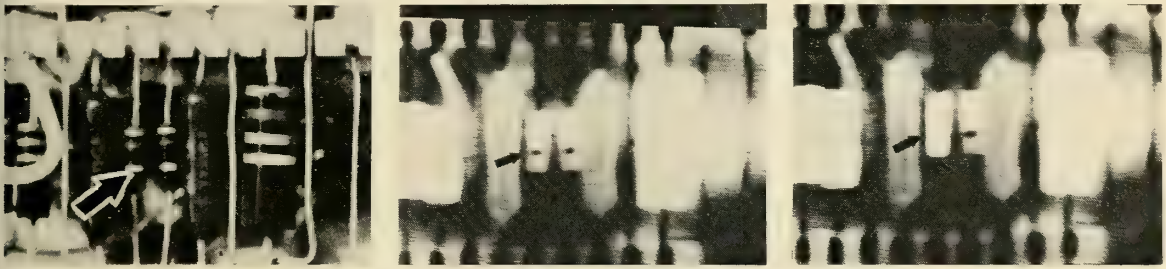
Although the standard Barnes camera can scan its target in six minutes, other models effect engineering trades between thermal sensitivity, pictorial resolution and speed. The standard



LEFT: A-3 Polaris second-stage rocket motor cooling after its removal from 110°F oven is ready for IR thermograph camera.



RIGHT: Defect is shown by dark shadow in lower part of picture. Black spots are silvery thermocouple pads.



LEFT: Part of conventional amplifier circuit board. MIDDLE: Thermogram shows circuit board components operating while (RIGHT) a later thermogram shows arrowed resistor hotter than earlier, indicating a defect in resistor or circuit.

camera has a 10x20 degree field-of-view, a spot size of one milliradian and a thermal sensitivity of the order of a tenth of a degree centigrade.

- **In other fields**—Yoder predicts expanding uses for the camera because of its ability to reveal a great many structural details in terms of a surface thermal pattern. The device can be used for inspecting all sorts of laminated structures, such as honeycomb. Even in some solid materials, flaws such as those in welds can sometimes be found: if there is an inherent symmetry in the structure, and a favorable balance of "through" thermal conductivity to a surface, as opposed to lateral thermal conductivity, patterns can be developed that reveal inner structures.

The IR thermograph method, since it uses no high-energy radiation, is nonhazardous to personnel and to sensitive devices such as semiconductors. The X-ray method suffers from these defects. Still, the X-ray technique can detect radial cracks on a cylindrical specimen, something the thermograph method can not easily do. The reason for this is that thermal energy would flow radially outward, and would see the crack essentially as a streamline and not be affected by it. The X-ray, though, affected by the amount of mass present, would clearly reveal the crack.

Yet the X-ray is lacking in the determination of such things as delaminations and voids in a filament-wound case. On a radial shot through a motor case, for instance, the thickness of mass present may not be altered; the X-ray will not show the fault unless a tangential shot is made. Even then, many tangential shots would have to be made in order to cover the entire circumference of the case. As a result, many hundreds of thousands of square feet of X-ray film, for the *Polaris A-3*, would have to be taken and analyzed.

It would appear that the IR thermographic method would be better in this instance because only two shots would be needed—of the front and back sides of the rocket motor case. A thermographic machine is also relatively inexpensive—typically costing approximately $26,000.

The IR thermograph system is also recommended for use wherever surface temperature measurements are wanted on an inaccessible target, or one too fragile or hazardous to touch. This includes measuring the temperature of components of a circuit board under operation in a vacuum chamber and perhaps simultaneously irradiated; or the surface temperature of a space vehicle in an environmental chamber, or of nuclear targets.

The system essentially is equivalent to a large harness of thermocouples—60,000 to be exact—whose outputs are coupled to a heat-sensitive plate and printed out. Any area in which such data can be useful is the province of the IR thermograph. ■

Ranger 7 met a noisy end.

Receiver noise filled out the last picture frame. Applause broke out around the world.

Now that the cheering has died down and the audience waits for the next two thrilling episodes of the Ranger program, we would like to make a modest statement about Northrop's contribution to Ranger.

It began with assistance to the National Aeronautics and Space Administration and Jet Propulsion Laboratory in the fabrication of sun and earth sensors.

We have since manufactured all of the sun and earth sensors used in the program.

We manufacture the central computer and sequencer.

We make the squib firing assembly which triggers the solar panels and starts and stops the midcourse correction motor.

Our picture
has been temporarily
interrupted.
Please stand by.

We provide various control electronic devices such as the autopilot and the sensor switching amplifier.

We provide support for the attitude control and midcourse correction systems and integrate the inertial sensors, the directional-antenna and jet-vane actuators, and the gas-jet regulators, valves, and nozzles for these systems.

These components and subsystems were awarded to Northrop one by one over the course of the Ranger program, and all of Northrop's modules have worked perfectly on every shot.

We continue to provide technical support to the Ranger program at JPL in the areas of system integration, quality assurance, and test and operations.

So although we are trying to be modest we are really quite proud.

NORTHROP

Beckman Defining Biomedical Tests For Air Force's MOL Flight Program

Firm also at work on NASA programs; Lockheed directing measurements for Apollo-X, MORL and LORL projects

by Heather M. David

DEVELOPMENT of a number of bioinstrumentation techniques for aerospace application has been undertaken by Beckman Instruments, for both NASA and Dept. of Defense space-station programs.

A number of biomedical tests already have been selected for performance during initial space-station flights. Beckman recently performed a state-of-the-art survey of available instrumentation for the Air Force *Manned Orbiting Laboratory* (*MOL*) program, recommending methods of conducting the measurements. A similar program is under way for NASA under the direction of Lockheed Missiles & Space Co. to determine measurements to be performed on *Apollo-X, Manned Orbiting Research Laboratory* (*MORL*) and *Large Orbiting Research Laboratory* (*LORL*).

The space-station requirements are for minimum sample preparation procedure, and ability to meet normal constraints of space travel—including weightlessness, acceleration, shock, vibration and temperature extremes.

The skill level of astronauts as medical experimenters will limit the types of biomedical tests to those which can be conducted—where necessary, even interpreted—by relatively untrained personnel. The NASA space-station program may include a physician or medical technologist aboard, but the individual tests are designed to minimize this requirement.

Another important factor is the limited amount of time which can be allotted to biomedical experiments.

Beckman scientist Walter Donner stresses the importance of limiting the experiments to those believed to be highly significant, which can be properly interpreted, and for which sufficient accuracy can be obtained. If trends are to be accurately observed, it is important to monitor all of the various body functions, including cardiovascular, central nervous system, gastro-intestinal tract, metabolism, renal function, pulmonary function and possible deterioration in the musculoskeletal system.

Final choice of biomedical experiments will represent the minimum requirement for sufficient information to aid in predicting long-term effects of extended weightlessness.

Million-lb.-Thrust Solid Successfully Tested by UTC for Fourth Time in Eight Weeks

UNITED TECHNOLOGY CENTER successfully test-fired its 120-in.-dia., 1-million-lb.-thrust solid-propellant rocket motor at Edwards AFB, Calif., on Dec. 22. The firing, lasting nearly two minutes, was the fourth static test within two months. The 250-ton rockets are being developed for the booster stage of the Air Force's Titan III-C standard space launch vehicle, under contract to the AF's Space Systems Division. The Titan III-C is scheduled to orbit a variety of manned and unmanned payloads, including the Manned Orbiting Laboratory. Other nose-down, static firings of Titan III-C booster rockets are scheduled this month at Edwards and at UTC's Coyote, Calif., test site.

- **Weightlessness concern**—Both NASA and the Air Force repeatedly indicated that the biggest concern is with possible effects of weightlessness upon the cardiovascular and musculoskeletal system. *Mercury* astronauts Walter Schirra and Gordon Cooper had evidence of orthostatic hypotension, in the form of pooling of blood in the legs and dizziness symptoms, after leaving their capsules. Several astronauts also had a slightly increased calcium excretion in the urine, which could signal loss of calcium from the skeletal system as a result of weightlessness. Both of these, however, could be caused by other stress factors of the flights.

Ground-based medical people will be looking for quick diagnosis techniques—vital information telemetered to ground stations for interpretation by qualified medical personnel. An important portion of this task will be the assessment of any serious degradation of a body system which would affect the astronaut's performance during re-entry and deciding whether countermeasures must be taken before re-entry is initiated.

Initial space-station missions, Donner said, probably will include the rate of blood, urine and feces samples together with other recorded data to permit expert analysis. The purpose will be to look for indices toward the development of suitable countermeasures for any effects noted.

- **CV conditioner**—Beckman is presently developing a cardiovascular conditioner which will be utilized in the forthcoming *Gemini* manned-orbital flights. The device will artificially stimulate blood circulation in the legs during prolonged periods of weightlessness and inactivity. It is typical of countermeasure techniques being studied, Donner said.

The device will operate a cuff surrounding the astronaut's thigh. A built-in timing device will automatically stimulate blood circulation at regular intervals, thereby preventing possible atrophy of the circulatory system from lack of use or effects of zero gravity.

Donner said that a comparison of evidence of orthostatic hypotension on the astronaut wearing the device with that of another astronaut not protected from this cardiovascular deconditioning will make it possible to assess the usefulness of this technique as a possible countermeasure.

Beckman is placing high priority on the study of equipment which would provide more than one biomedical measurement. Sophisticated equipment is stressed, since according to Donner, "it is not merely necessary to detect the presence of a component, but small changes in its concentration in body fluids must be carefully monitored over a period of thirty days or more."

Biomedical measurements performed in *Mercury* have been limited because of weight, volume and other operational constraints. These measurements of pulse rate, blood pressure and respiration determined gross trends only.

However, these measurements did indicate a decrease in the ability of the cardiovascular system to compensate for adverse circumstances and changes in its function. These are considered the most probable areas of disturbance. This impaired ability may be compensated for, the company indicated, by a possible decreased blood and extra-cellular fluid volume under weightlessness conditions because of a reduced workload and decreased tissue oxygen needs. This could lead to blood pooling and redistribution of the body fluids.

Bedrest studies have demonstrated that a decrease in blood volume does occur. Various dilution techniques for measuring blood volume are being considered.

Total body water measurement

Parker

METAL V-SEAL

A RELIABLE WEIGHT REDUCING SEAL FOR EXTREME ENVIRONMENTS

Today's engineer must cope with such environments as temperatures ranging from —423°F. to plus 2000°F., from hard vacuum to high pressures, and exposure to extremely volatile and corrosive media or radiation. Parker's Metal V-Seal represents a significant achievement in the search for an effective, economical and weight reducing static face seal to meet these extreme demands . . . Designed, engineered and made to Parker's high standards of quality and dependability.

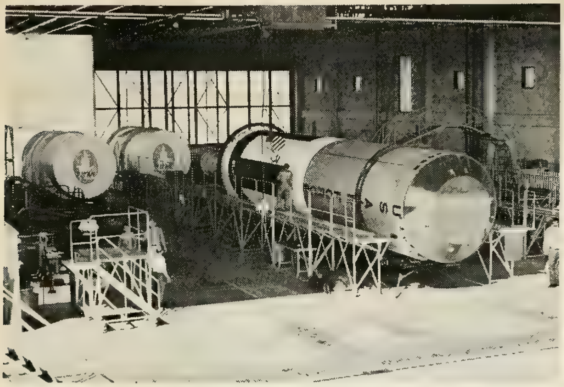
8 BASIC ADVANTAGES:

- "Zero" leakage even with the lightest gases
- High resistance to corrosive and volatile chemicals
- Low flange loads to minimize system weights
- High resiliency to compensate for flange deflections
- No special flange machining required (can be made to fit almost any existing groove and some styles do not even need a groove!)
- Reusable several times under most conditions
- Wide variety of seal metals, platings, and coatings to meet specific requirements
- Full range of standard sizes from ¼" to 15" O.D. (Larger on special order)

Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio

Want more information?
Send for Catalog 8800

Circle No. 2 on Subscriber Service Card



Titan III-A Stages at The Cape

THE MARTIN Co. engineers check three stages of first AF Titan III-A scheduled to launch an active satellite into Earth orbit. Booster is due for launch in February.

would provide important information on fluid balance and transport. Standard techniques include injecting or swallowing a substance, taking blood and urine samples, and measuring the amount of dilution, Beckman said.

The possibility of evaluating cardiac output by oxygen uptake and carbon dioxide production is also being studied by Beckman. A research program has just been completed to evaluate a gas-monitoring device produced by the company which continually measures both CO_2 and O_2 partial pressure, on a breath-by-breath basis, in conjunction with a flowmeter.

This work, performed for the Flight Research Center at Edwards AFB, Calif., utilized a fast-responding polarographic oxygen sensor and an infrared pO_2 analyzer.

Beckman is also studying the possibility of utilizing parotid secretions—the fluid released from the glands just forward of the ears—for instantaneous information on stress, as well as routine measurements on various biomedical tests.

If changes in blood composition could be satisfactorily monitored by utilizing parotid secretion, this would obviate the necessity for drawing blood; the fluid is easily obtained by application of a simple suction cup placed over a parotid gland in the mouth.

Beckman presently is conducting a research program to establish baselines and to evaluate the usefulness of parotid secretions for determining blood values for a variety of constituents.

- **Demineralization**—Spaceflights of both the United States and the Soviet Union have indicated a slight loss of calcium through the urine. However, it has not been determined whether this is a transient effect or the beginning of a trend. Both on-board and post-flight tests should be made, Beckman feels.

By specifying the exact amount of calcium in the diet and then measuring that excreted, the amount of demineralization in the bones can be determined. It is desirable that a measurement of bone plasma and urine calcium be made, Donner added.

Since the astronauts all had a relatively large weight loss, and fluid imbalance which has been attributed to extensive dehydration, it is important to determine whether the fluid loss was due to poor temperature regulation with periods of stress, or whether prolonged weightlessness will cause serious fluid balance shifts.

- **Renal problems**—There is also the possibility that extended weightlessness, with possible changes in blood volume, will produce changes in kidney function. Since blood hematocrit rises with a loss in total body water, this measurement would be helpful. If a blood volume measurement can be made, it might also be helpful in assessing renal function, Donner said.

Measurement of blood and urine electrolysis is important, Donner said. Sodium and potassium ions, for example, are mainly responsible for maintaining body-fluid osmotic pressure. If the sodium-potassium ratio were found to be lowered, it might indicate that a high rate of tissue destruction or cellular turnover was taking place.

Beckman has developed a spaceborne pH meter which permits the measurement of hydrogen ion concentration under conditions of weightlessness. Qualified units have recently been delivered to North American Aviation for the monitoring of *Apollo* fuel-cell water. Slight modifications of this instrument can be made to permit the direct measurement of sodium and possibly potassium in various body fluids, Beckman said.

A single-purpose instrument such as a flame photometer is also being considered for the measurement of the electrolyte. By combining a dissolved carbon dioxide measurement with plasma pH, important metabolic changes can be detected as an upset in the acid/base equilibrium.

Beckman has already developed a glass electrode technique which will directly measure pCO_2 in blood. This electrode could be combined with the pH measurement in a single flyable unit, Donner said.

- **Respiratory system**—The actual mechanism of respiration in weightlessness should not be changed in spaceflight, since the same muscles do about the same amount of work, as long as oxygen and carbon dioxide partial pressures are maintained within the proper limits. It is not expected that the gas-exchange efficiency of the lung alveoli will be affected by weightlessness.

However, the demands of the body in the weightless state may cause a decrease in oxygen consumption. This would result in significant changes in vital capacity and respiratory rate, especially if the efficiency of gas exchange is not changed.

Respiratory function is one of two mechanisms which affect the acid/base balance of the blood. Since the effects of weightlessness on this balance are not known, it is considered important to determine whether a shift is caused by alterations in ventilation or by kidney function.

The partial pressure of carbon dioxide in the alveoli of the lungs also provides an index of acid/base balance plus indicating metabolic rate when compared with oxygen uptake. Exhaled pCO_2 can be used as an indication of carbon dioxide tension in the blood, and used as a measurement instead of actually monitoring venous carbon dioxide.

Oxygen consumption and carbon dioxide measurements are extremely important in terms of assessing the adaptation to the environment and as a measure of work and energy requirements under dynamic conditions. They are also important in assessing future logistics requirements for longer space missions.

- **Phonocardiogram**—In addition to biochemical tests, Beckman is actively engaged in the development of physiological instrumentation. A phonocardiogram has been delivered to NASA's Manned Spacecraft Center to monitor heart sounds of the astronauts.

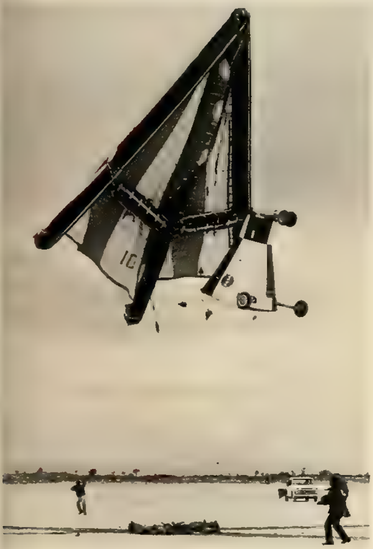
The unit, operating as a remote stethoscope, can monitor heart signals continuously during the flight for on-board recording and later evaluation to give a heart-beat check on the conditions of the astronauts.

The system consists of a miniaturized microphone to be attached to the chest and an amplifier unit.

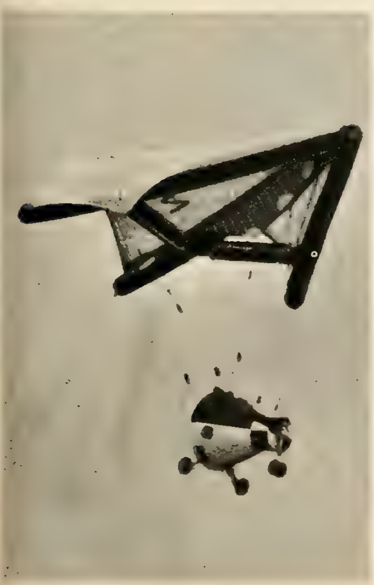
Beckman is also developing a miniaturized electroencephalograph for monitoring brain waves. The system, consisting of electrodes and an amplifier unit, will collect and condition the data for telemetering back to Earth. This information will aid in determination of the alertness of the astronaut at specific times during the mission. ■

First Manned Flight of Gemini-Type Glider Called Proof of Feasibility

by Willard E. Wilks



TEST PILOT McCusker, in dummy Gemini capsule with paraglider, is towed aloft (above) and later maneuvers (below).



PALMDALE, CALIF.—North American Aviation has completed the first manned flight with a full-scale *Gemini*-type inflatable paraglider recovery system. The pilot was severely jarred on landing.

The flight with a 2,850-lb. dummy *Gemini* capsule here Dec. 19 ended the Space & Information Systems Division's (SISD) $22-million contract with NASA's Manned Spacecraft Center at Houston. The division indicates it will continue development with in-house funding, although further NASA funds may be forthcoming.

Test pilot Donald F. McCusker landed at higher speed than anticipated, apparently because he failed to flare out quickly enough, and he was hospitalized for about two weeks with a compressed vertebra.

George Jeffs, division vice president and paraglider program manager, said the flight "demonstrated that the paraglider is a feasible way to land a spacecraft at a pre-selected area on dry land."

- **Imponderables**—The NAA paraglider concept was considered earlier as a good possibility for the *Gemini* recovery system, but a NASA spokesman said development had not proceeded rapidly enough. The program suffered a setback on Aug. 7, when the tow test vehicle (TTV) crashed after the pilot was forced to bail out because of stability control problems.

However, the paraglider is not necessarily ruled out as a possibility for *Gemini*—if NAA can successfully demonstrate pinpoint manned landings. Land recovery would be preferable for *Gemini*. NASA also is investigating a parasail approach being developed by Pioneer Parachute Co. of Canada, Ltd. Either of these systems, successfully developed, would permit steerable recovery on land.

At present, however, both are research programs and not part of the *Gemini* program. The designated *Gemini* recovery system is that developed by Northrop, also a steerable parachute with a lift-drag ratio better than 2.

Officially, a NASA spokesman said, there is no competition among these systems for *Gemini*, and the Northrop system will be utilized. However, since *Gemini* and *Apollo* are the only two second-generation spacecraft from which design requirements can be generated, the paraglider and parasail systems are centered on meeting *Gemini* requirements.

- **Good glide**—In the latest flight of NAA's system, the TTV with paraglider wing attached and deployed was towed to 8,500 ft. by a Sikorsky S-61 helicopter and released for glide return to Earth. During the 4-min., 10-sec. flight, the pilot performed various maneuvers, including S-turns and 180-deg. turns, to investigate lateral response throughout the pitch range. The wing performed satisfactorily at various pitch settings and in checkout of roll response from low to high angles of attack.

Noting that there had been some question about the wing's all-weather capabilities, NAA said the craft disappeared into clouds on a number of occasions.

Speed during the glide portion of the flight ranged from 25 mph. to 45 mph. Landing speed was the planned 25 mph, but the sink rate was greater than expected.

The company said it now will proceed with the next phase of the program —refinement of the system for manned pinpoint land recovery.

- **Development system**—The paraglider used now is 31 ft. long, with a 31-ft. wingspan. Fabricated of neoprene-coated Dacron and Fortrell and inflated with nitrogen gas, it would be stored in a 10-cu.-ft. canister aboard a *Gemini*.

The remaining nitrogen would be used to activate gas motors to control the cables that attach the wing to the capsule, reeling them in and out as necessary to control flight during atmospheric glide after re-entry.

The flexible cable system is attached at three points along the paraglider keel, and at one point on each boom. This controls pitch and roll, the pilot using a *Gemini*-type stick. ■

Highly Advanced Telemetry Complex Going in at Eastern Test Range

Developed by Defense Electronics, Inc., $8-million system may be model for missile/space data acquisition for decade

by Charles D. LaFond

TRACKING AND RECORDING of data from all future missile and space vehicle launches from Cape Kennedy will, by the end of this year, be handled by a new and extremely versatile ground telemetry complex employing predetection recording techniques.

Developed under an $8-million program by Defense Electronics, Inc., Rockville, Md., for the Air Force, the big 15-rack system will be installed throughout the Eastern Test Range. Capable of handling up to 12 channels simultaneously, it also will be capable of use with any state-of-the-art telemetry approach now available or planned.

The basic system provides dual-diversity reception for optimum signal selection without the introduction of degrading signal by-products or the need for special phase correlation.

- **Background**—In June, 1963, DEI topped 15 bidders and was awarded a $6-million, two-year contract from the Air Force out of Patrick AFB, Fla., to develop and build telemetry ground systems to improve both the receive and record capability on the Eastern Test Range. Later, with add-on's, the total contract figure approached $8 million.

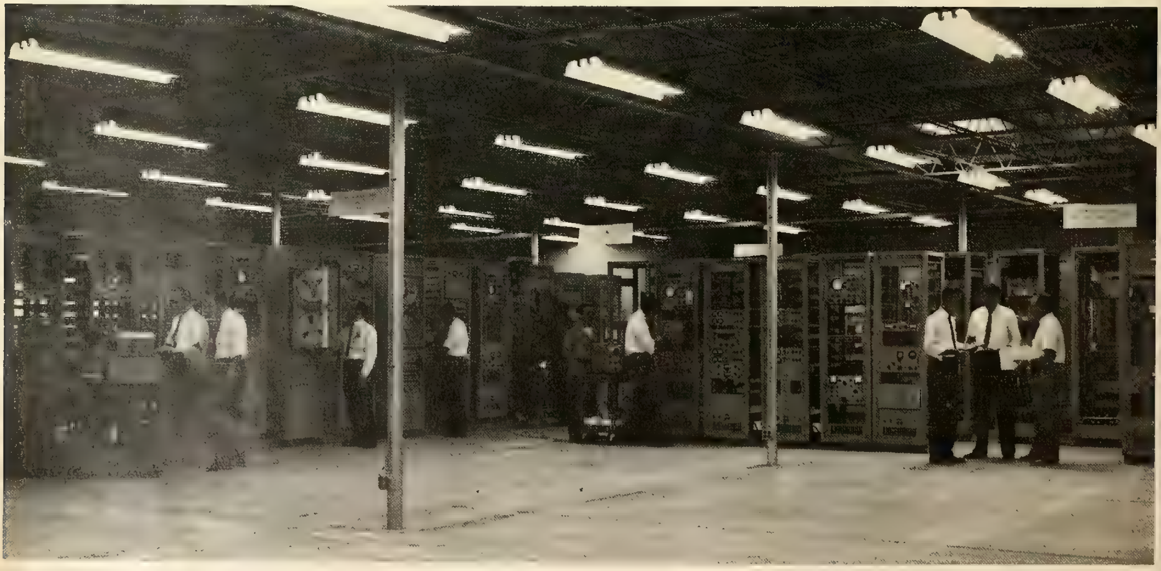
The first system prototype was delivered last summer (July 27). Under the present contracts, 18 more fully operational systems will be built and delivered for installation throughout the range. The equivalent of 17 more will be supplied by mid-1965 in the form of spares and ancillary subsystems for the basic operational systems.

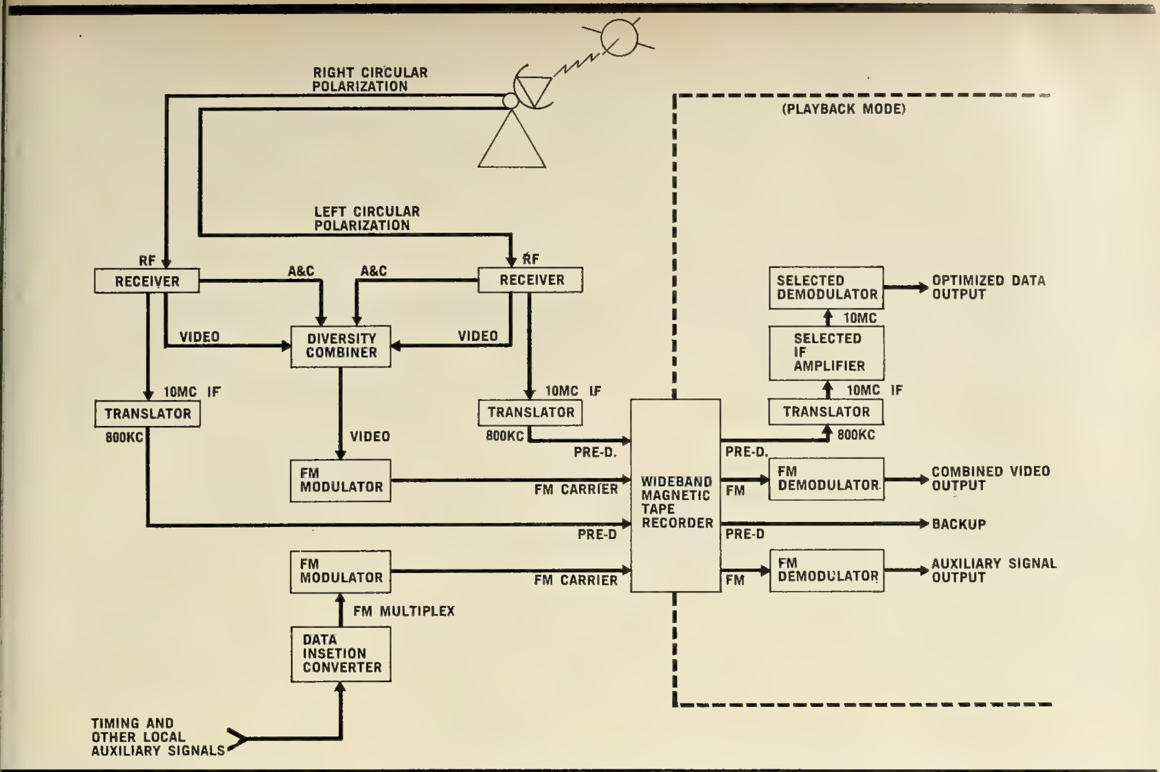
At least two complete systems will be installed at Cape Kennedy. The remaining 17 systems will be employed by all the major stations downrange.

In addition to its ETR contract, DEI is supplying about six more systems under a Navy contract for Western Test Range instrumentation ships. Also, NASA's Goddard Space Flight Center has purchased an undisclosed number of subsystems for its global tracking net. The AEC has made similar purchases.

Reportedly, the Air Force's Electronic Systems Division is now budgeting to purchase additional subsystems

TRKI-12 PREDETECTION Receive/Record Group, developed by Defense Electronics, Inc., for Air Force, will be used to update Eastern Test Range telemetry system. It will be operational late this year.




RIGHT CIRCULAR POLARIZATION
LEFT CIRCULAR POLARIZATION
(PLAYBACK MODE)
RF
RECEIVER
A&C
A&C
RF
RECEIVER
VIDEO
DIVERSITY COMBINER
VIDEO
10MC IF
TRANSLATOR
800KC
VIDEO
10MC IF
TRANSLATOR
800KC
PRE-D.
FM MODULATOR
FM CARRIER
WIDEBAND MAGNETIC TAPE RECORDER
PRE-D
FM MODULATOR
FM CARRIER
FM MULTIPLEX
DATA INSETION CONVERTER
TIMING AND OTHER LOCAL AUXILIARY SIGNALS
SELECTED DEMODULATOR
OPTIMIZED DATA OUTPUT
10MC
SELECTED IF AMPLIFIER
10MC IF
TRANSLATOR
800KC
PRE-D.
FM
FM DEMODULATOR
COMBINED VIDEO OUTPUT
PRE-D
BACKUP
FM
FM DEMODULATOR
AUXILIARY SIGNAL OUTPUT

SIMPLIFIED BLOCK DIAGRAM of TRKI-12 system as designed for its missile/space data acquisition role.

for installation aboard all its range tracking aircraft.

- **System need**—On the surface, the need for updating Eastern Test Range telemetry systems is reflected by the usual pat requirements for greater flexibility, reliability, standardization and the need to replace nearly worn-out subsystems—some in operation for 12 years.

Another need, however, from an Air Force point of view, has deeper political roots. The space agency is currently the largest range user, and, according to many industry observers, it would like to have more significant control over the range. Existing range telemetry systems meet IRIG (Inter-Range Instrumentation Group) standards, yet NASA, they say, all too frequently institutes non-standard requirements for specific missions (frequencies, format, etc.). The result, observers claim, is intermittent confusion.

Under present policies, non-standard equipment users must supply the necessary funds for mission support subsystems downrange, thus NASA equipment selections appear intentional, not accidental.

Also, some range personnel disclosed to Missiles and Rockets, NASA has shown a tendency in the past to withhold telemetry-requirement information until the last possible minute, thus forcing Air Force embarrassment through the difficulty in satisfying NASA needs. The obvious results, informants charge, are panic procurements demanding a short-time delivery.

So far, they disclosed, the Air Force has met NASA needs but with unnecessary difficulty.

By means of the new DEI equipment, Air Force range officials believe they have a system so versatile and flexible that with simple modification, any future telemetry need can be met. Only module replacements are needed throughout a few of the 15 racks of equipment in the new system to meet any future need.

With the first prototype accepted, DEI is now in full production and the systems are expected to be operational throughout the range late this year.

- **System description**—The TRKI-12 Predetection Receive/Record Group is a fully integrated, complete telemetry system capable of handling simultaneously up to 12 telemetry signals of any known or projected modulation format, according to Victor A. Ratner, DEI's director of advanced planning.

In general, the new system employs dual redundancy, but all channels can be employed as needed in operation.

It utilizes dual-diversity reception. New antennas employing 60-ft. dishes and advanced feed systems are being built by Radiation, Inc., and Antenna Systems, Inc. The old tri-helix range antennas are being replaced by 30-ft. dishes as prime telemetry trackers. It is expected that some 85-ft. dishes with broadband feeds will be required for long-range mission support.

Frequency translation techniques, imbued in system design, permit recording and reproduction of high bit-rate PCM and other wide-bandwidth signals with minimum distortion, Ratner said.

Other system design highlights include the following:

—Coverage of all allocated telemetry bands between 100 and 1,000 mc;

—Maximum predetection recording bandwidth of 1.4 mc;

—Playback IF bandwidth selections from 10 kc to 1.5 mc, "real-time" IF bandwidths to 3.3 mc;

—Capability for recording detected signals from true DC to 500 kc;

—Post-detection dual-diversity combining of up to six links;

—Provision of complete coaxial patch-board programming and a video distribution network;

—Capability for time-base expansion or contraction of PCM signals;

—Facilities for receiving and recording AM, FM, PM and SS modulation.

Believed by its developers to be the first system of its kind successfully built and tested, it could very well set the standard for missile/space data acquisition on U.S. ranges for a decade. ■

Ionospheric Satellites Aiding Design of Long Antenna Systems

Several programs could benefit; ISIS project advances; results from Explorer XX may lead to spin-control apparatus

by Michael Getler

THE U.S. AND CANADIAN program to explore the ionosphere using jointly developed satellites and experimental payloads is not only providing large amounts of useful scientific data but is also contributing to future development of very long, extendable structures for use in space as antennas and attitude stabilization booms.

Canada's *Alouette-1* topside sounder satellite, launched in September, 1962, and still functioning, has two sets of on-board antennas, one set measuring 75 ft. tip-to-tip, and the other, 150 ft. The U.S. topside sounder, *Explorer XX (S-48),* launched in August, 1964, and still operating, has two sets which measure 60 ft. tip-to-tip, and one set measuring 120 ft.

Future satellites now under development in the joint U.S.-Canadian *ISIS* (*International Satellites for Ionospheric Studies*) program will have antennas on-board with tip-to-tip measurements of at least 240 ft., and possibly longer. The development of future *Radio Astronomy Satellites* by NASA (M/R, Nov. 30, p. 92), an item now under study within the FY'66 budget request, will probably require a pair of antennas each extending possibly 750-1,000 ft.

These long antennas will permit radio astronomy experiments to be carried out by means of satellites in the relatively low frequency range from about 8-10 mc down to perhaps 1 mc, a range not practicable with Earth-based sensors because of ionospheric blocking.

There is also considerable interest in using these booms operationally aboard satellites in a dual role as electronic antennas and as passive gravity-gradient satellite stabilization devices, though the very long lengths that would be associated with radio astronomy would not be necessary solely for stabilization.

NASA's *Applications Technology Satellite* will carry out important gravity-gradient experiments at both medium and synchronous satellite altitudes (M/R, Nov. 30, p. 94).

Scientists at NASA's Goddard Space Flight Center are now nearing completion of an in-house study aimed at determining feasibility of these very long antennas that could have an important bearing on the fate of future developments of the *Radio Astronomy Satellite.*

- **Gravity and heating problems**—The technique for actually extending an antenna to long distances from satellites is believed to be pretty well in existence. Scientists point out that aboard satellites, there is plenty of time for the extension operation. For example, the electrically driven booms aboard the current topside sounders go out at the rate of about 2½ ft. per min. It takes about 24 minutes to fully extend the two 60-ft. booms aboard *Explorer XX.* Antenna systems on both satellites are of the STEM (Stored Tubular Extendible Member) type made by the de Havilland Aircraft of Canada, Ltd.

However, there are two major problems to contend with once the booms are extended. One involves bending due to gravity and the other bending caused by thermal effects. Either can cause perturbations in satellite motion and also can seriously distort the radiation pattern of the antennas. The thermal problem can be reduced somewhat if the satellite is spinning in orbit. However, as the spin rate decays, possibly due to the drag of gravity on the long booms, the heating on more exposed portions of the boom can cause antenna problems. At GSFC, there is serious consideration being given to plating antennas, possibly with silver, to reduce the thermal bending effects on future *ISIS* satellites.

While the ability to extend long antennas from satellites appears to be reasonably well in hand, there may be fruitful development work to be done in very rapid antenna deployment schemes for low-cost rocket-borne probes and radio astronomy measurements, where only about 20 minutes of actual observation time is available. Scientists say that antennas 50-100 ft. long look feasible for this role, but will require more engineering development.

Among the methods known to be of interest for this role is a technique in which beryllium copper is heated and pre-stressed in a cylindrical shape and then flattened into a roll so that when it is released the stored energy within the roll causes the metal to rapidly re-form its cylindrical shape and spring forward. The technique is basically the same as the electrically-controlled STEM, but without the motor. De Havilland is also known to be pursuing research in this area. While this technique might require some sort of a braking system for control, it would have an advantage in the overall reduction of electro-mechanical components needed for extension, a troublesome area in the space environment.

- **Spin-rate decay**—In the more than two years that *Alouette-1* has been aloft, the spin rate of the satellite has slowed from 1.5 rpm to a current rate of about 0.2 rpm. While a degradation in the spin rate was predicted, the rate is faster than that originally estimated. Though scientists are not sure of the exact reason, it is believed due to a mechanical hysteresis loss associated with the long and flexible antennas.

Explorer XX, now up about four months, is beginning to develop the same type of pattern, and there is evidence that the spin decay is actually faster than that of *Alouette-1,* going from 1.5 rpm to 1.1 rpm in the four-month period. This may be caused, scientists speculate, by the even more flexible antennas used aboard *Explorer XX.*

The antennas used aboard *Alouette-1* are made of 4-mil-thick steel with a 1-in. unfurled diameter. In the *Explorer XX* design, NASA chose to use a 2-mil-thick beryllium-copper antenna with a ½-in. unfurled diameter.

The total weight of all six antennas aboard *Explorer XX* and individual electrical drive units for each antenna is 10.4 lbs. The total weight of the four antennas aboard *Alouette-1* and a single drive system is 45 lbs. While *Explorer XX* has more antennas, the total antenna lengths associated with the two satellites are about equal. One of the major gains that the lightweight beryllium-copper devices allowed satellite designers was the use of individual drives for each antenna, which improved reliability and provided confidence that even a partial failure would allow some of the experiments to be carried out.

The continued comparison of performance and spin-rate decay between the satellites, and particularly noting the effect of the beryllium-copper antennas upon the *Explorer XX* spin rate, is expected to influence a NASA decision of whether to put some kind of spin control system aboard future *ISIS* satellites. This would more than likely be accomplished with an aluminum coil arrangement around the spacecraft through which electronic current could be passed so that its interaction with the surrounding magnetic field could be used to speed up the satellite spin. Even with the inclusion of such a system, NASA scientists believe there will still be substantial advantage in using the beryllium-copper antennas. They point out the spin control would still be needed even with very long steel antennas.

- **ISIS program progress**—The *ISIS* program, initiated in January as a joint U.S.-Canadian program of upper ionosphere research, is basically a continuation of the long-standing space research program in this area, most recently typified by the two topside sounding satellites and the *Beacon Explorer* (M/R, Oct. 19, p. 11). *ISIS* involves launching five more satellites in four launchings between 1965 and 1970, which would correspond to solar cycle minimum and maximum periods.

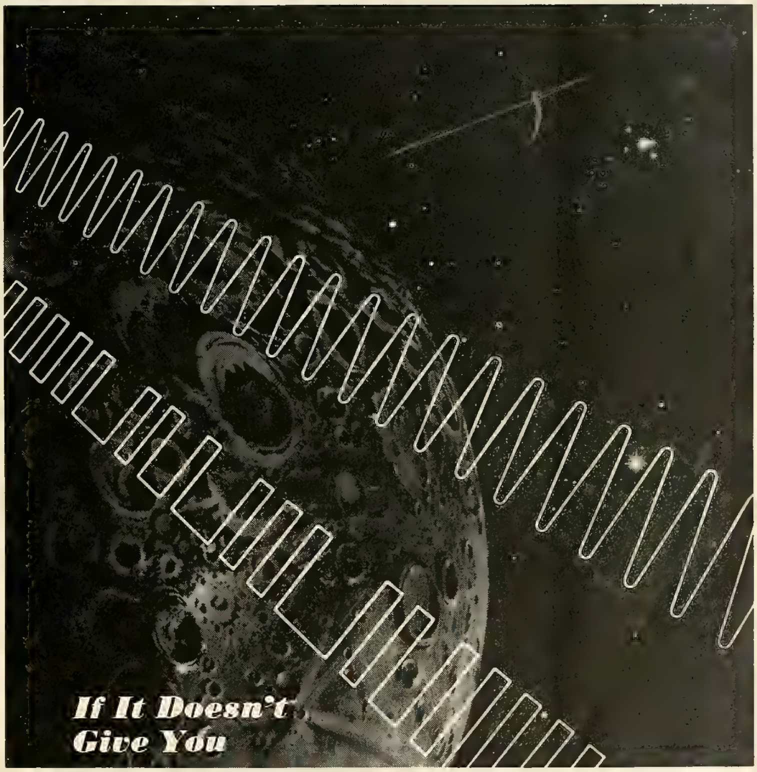
The ionospheric research program thus far has involved data collection employing four basic techniques: sounding rocket vertical measurements; three different types of satellite observation typified by topside sounding vehicles such as *Alouette-1* and *Explorer XX;* the direct measurement approach such as that used on *Explorer VIII;* and the ionospheric beacon technique on *Explorer XXII.*

The *ISIS* program is basically an attempt to combine these three satellite techniques into a single satellite wherever possible to get correlated data and also to gather data in different orbits, at different altitudes, and during different periods of solar activity (which can greatly affect the ionosphere).

While topside sounding has yielded excellent data thus far for developing electronic density profiles of the ionosphere and is a primary area to be expanded upon during the *ISIS* program, project scientists would also like to discover such things as relative distribution of oxygen, hydrogen, and helium ions at all altitudes, and their respective temperatures.

The *ISIS* program as now envisioned involves about $25 million in flight hardware costs. The four launchings will be carried out by a *Thor-Agena-B* and three *Delta's,* with a combined vehicle cost estimated at about $17 million. About $7 million will be for the *Thor-Agena-B,* which will put a double payload into orbit. Four of the five satellites in the program will be built in Canada and the total payload costs are estimated at $8.9 million, officials say.

Most of the launchings are to take place from the Western Test Range in order to get high-inclination orbit and wide-latitude coverage for the satellites.



BACK TALK A Space Shot Is A Failure!

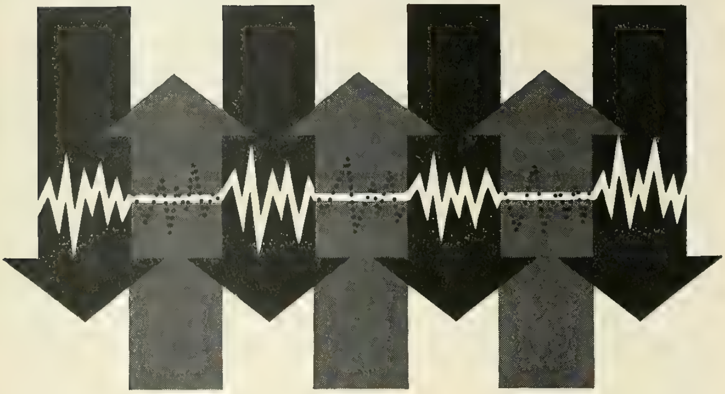
A space probe is successful only when the information it is sent to gather is relayed back to earth. The value of manned and unmanned vehicles hinges on the reliability of the telemetry equipment. We take pride in the fact that many missiles contractors, impressed by the reliable performance of Conic telemetry transmitters, have entrusted us with the responsibility of a successful missile probe. Conic's multi-purpose airborne telemetry equipment includes sub-carrier oscillators, transmitters, receivers, RF, Audio and DC amplifiers. Space system engineers are assured of prompt delivery and on-site liaison when specifying Conic systems or components.

CONIC Corporation
7915 Balboa Avenue • San Diego, California 92111

Circle No. 4 on Subscriber Service Card

Data Handling and Communications Engineers/Information Theorists

data squeeze



compacting data to increase the transmission capability of the Eastern Test Range

To meet the future demands of range users for transmission of large amounts of trajectory, telemetry, bioastronautic, and color television data from space vehicle to central control at the Cape, Pan Am engineers are studying various compaction techniques that may permit essential information received at the rate of over 1.5 million bits per second to be transmitted over existing narrow-band channels with a 3000 bit/sec capacity.

The feasibility of some 20 compaction methods are being analyzed, including combinations of data adaption, pulse compression, multiplexing, etc. Models are being set up using simulated and real data to determine the necessary trade-offs on compaction vs accuracy. Graduate engineers who can contribute to this effort and to the development of other systems for data processing and real-time computing, digital data transmission, range safety display, target acquisition, and analog-digital conversion are invited to write in confidence to Manager, Professional Employment, Dept. 56A-1.

PAN AM

GUIDED MISSILES
RANGE DIVISION
PAN AMERICAN WORLD AIRWAYS, INC.
750 S. ORLANDO AVENUE, COCOA BEACH, FLORIDA
An Equal Opportunity Employer

Circle No. 3 on Subscriber Service Card

However, one low-inclination launching is possible from the Eastern Test Range.

The following is an up-to-date breakdown of the progress in the satellite development effort:

- **ISIS-X**—This is the collective name for a two-satellite payload that will lead off the program with a late-1965 launching from WTR. The payload includes the 326-lb. *Alouette-2* (which was the back-up spacecraft for *Alouette-1*, now modified for the new program), and a new 190-lb. *Direct Measurement Explorer-A* (*DMEA*) satellite. Both satellites will be placed into the same orbit, "reasonably close together," according to NASA, to aid in data correlation. The orbit will be elliptical (in comparison to the circular 1,000-km orbit of *Alouette-1*) with an apogee of about 3,000 km and a perigee of 500 km and an orbital inclination of about 80 deg. for wide latitude coverage, allowing data collection at all hours of day and night over about a three-month period. The satellite will have a 3½-hr. daily operating minimum.

NASA scientists explain that while the intent of the program was to put as much as possible into a single satellite, the direct measurement satellite "went its own way" because of the rather delicate measurements involved. These are concerned mostly with measuring the environment in the immediate vicinity of the spacecraft, and equipment might have difficulty functioning if that environment were disturbed.

Therefore, for *ISIS-X*, two separate payloads will be used, but direct measurement equipment will also be included in the *Alouette* design for comparison purposes and also to test feasibility for making these experiments from a topside sounder.

The disturbances scientists are primarily concerned about also relate to antenna design. A conducting antenna moving through a magnetic field could set up a potential across the antenna which could disturb electrically charged particles in the vicinity. To counter this possibility, some changes in antenna design will be made in the form of a d-c barrier or isolation scheme, such as a capacative coupling, to electrically isolate the antenna and spacecraft.

Alouette-2, like all the *ISIS* satellites except the *DMEA*, is the responsibility of Canada's Defence Research Telecommunications Establishment (DRTE). Principal contractors are de Havilland, for the antennas and mechanical structure of the satellite, and RCA of Canada for the major electrical systems.

The satellite will carry five experiments: a swept frequency topside sounder, cosmic noise experiment, and VLF receiver, all being supplied by DRTE: an energetic particle detector being provided by the Canadian National Research Council; and an electrostatic probe supplied by Goddard.

The primary experiment aboard *Alouette-2* will be the swept frequency topside sounder, which is basically the same as the device currently providing excellent ionospheric profiles aboard *Alouette-1*. However, the *Alouette-2* device, because of its higher orbital altitude and coverage, will be extended in its low-frequency range, requiring a set of 120-ft. antennas (240 ft. tip-to-tip).

The satellite is nearing completion and is about to enter the test stage.

The *DMEA*, being built by the Applied Physics Lab of Johns Hopkins University, includes six experiments, four of which are being provided by Goddard—ion retarding potential, electron retarding potential, energetic electron current monitor, and electrostatic probe; one by the Naval Research Lab—high resolution ion mass spectrometer; and two by the British—electron temperature probe and spherical ion mass spectrometer.

- **ISIS-A**—The third satellite (second launching) in the series is a 500-lb. craft slated to be orbited by a *Delta* vehicle about a year after *ISIS-X*. This satellite will include: a fixed-frequency topside sounder (to be built by the Canadians) similar to the one now operating successfully aboard *Explorer XX;* direct-measurement equipment (NASA is confident that *ISIS-X* inputs will solve problems associated with these measurements made from a topside sounder. One solution other than antenna redesign may simply be to alternate experiment turn-on); an ionospheric beacon system similar to the one now operating aboard *Explorer XXII;* VLF experiments; and a number of the relatively small cosmic ray and particle detector packages.

This satellite may be the first to incorporate the spin control electronics previously mentioned and the antenna coating.

ISIS-A is said to be well into the design stage, with experiments selected, prototype packages under development, and a model already constructed.

This spacecraft will also include a new experiment by the Graduate Research Center of the Southwest (Dallas), and two Air Force experiments supplied by Cambridge Research Laboratories.

Project officials point out that virtually all of the pre-NASA ionospheric research was carried out by the Air Force, but that selection of Air Force experimenters merely reflects the high level of competence in this area and not that the experiments are aimed at military application.

There is, however, considerable military interest in the ionosphere for communications and radar requirements, in general, and while the Air Force no longer runs the program, DOD scientists are known to sit in on meetings.

Satellites of the topside sounder type have also been postulated by some observers for other military applications, such as in an early warning role for detecting vehicles launched through the ionosphere and also as a means to rapidly determine critical communications frequencies for an ionosphere that has been grossly disturbed by a nuclear explosion.

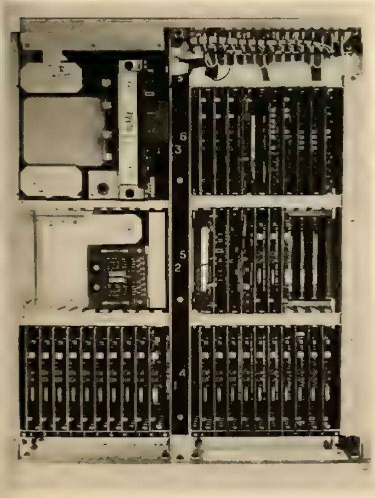
- **ISIS B and C**—Beyond *ISIS-A*, very little is firm. Project officials at Goddard say it will be 6-12 months before RFP's go out on the *ISIS-B* experiments, and that the details on the last satellite "are completely indefinite." At least one of these is expected to be similar to *ISIS-A* and will probably be launched during a period of maximum Sunspot activity, but with a higher apogee than *ISIS-A* and *X*.

While the *ISIS* program advances, scientists at NASA and the National Bureau of Standards' Central Radio Propagation Laboratory in Colorado are sifting through *Explorer XX* data.

- **Explorer XX observations.**—Early scientific observation of data indicates that the satellite (M/R, Feb. 10, p. 31), designed and built by the Airborne Instrument Laboratory Div. of Cutler-Hammer, Inc., is yielding verification data on some expected ionospheric features and has also added data on some newly observed conditions.

A main purpose of the satellite, according to NASA, is to study ionospheric irregularities ranging in size from 1 to 100 km using its series of fixed frequency soundings, something that was not possible with the swept frequency measurements taken aboard *Alouette-1*. The *Explorer XX* also allows a greater received signal amplitude because of optimum antenna matching at each frequency.

As a result, scientists say a great deal of new data concerning ionospheric resonance effects is being produced. Also, new observations to date indicate dimensions of patches of so-called Sporadic-E, which were not measurable with the 100-km horizontal resolution of *Alouette-1*. New observations have also been made concerning thickness of echo-producing "ionization sheets," the existence of which had been previously only postulated to explain certain *Alouette-1* observations. ■



SPACE ELECTRONICS

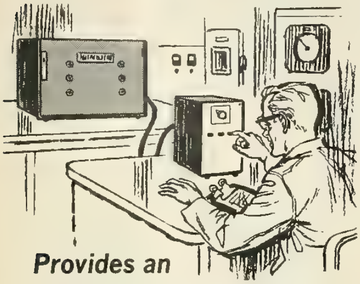
New Product of the Week: Data Distributor

The model 670 data distributor series, designed to convert computed data to analog form under computer control and distribute the converted data to the proper analog output channel, is available from the Redcor Corp.

Specifications are: gain: unity with polarity of all ones= —full scale output and all zeros= +full scale output; accuracy of ±0.02% @ DC; linearity of ±0.01% @ DC; drift, ±500 μvolts and ±100 μvolts/°C; noise, 2 MVolts peak to peak RTO; output, ±10v @ 10 Ma short circuit proof; decommutation rate, 50 KC/S to within ±0.02%; sample time, 30 μsecs. to within ±0.02% for 20v full scale excursion; hold conditions, uncertainty of ±0.01% max., decay of ±0.01%/millisec., temp. coeff. of 0.001%/millisec./°C; input, data of up to 17 bit decimal 14 bit binary, address of up to 7 bit binary (104 channels max.), Strobe of 8v change either polarity 0.1 μsec. transition; digital signal levels of 0 ± 0.SV= logical "O" and —9 ± 3V=logical "1".

Circle No. 151 on Subscriber Service Card

MISSIMERS
PRECISION
SERIES
TEST CHAMBERS

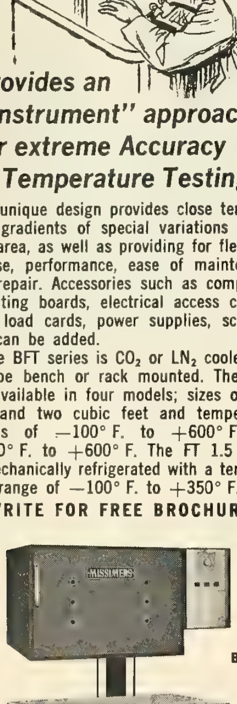


Provides an "Instrument" approach for extreme Accuracy in Temperature Testing

This unique design provides close temperature gradients of special variations in the test area, as well as providing for flexibility of use, performance, ease of maintenance and repair. Accessories such as component mounting boards, electrical access connectors, load cards, power supplies, scanners etc. can be added.

The BFT series is CO_2 or LN_2 cooled and can be bench or rack mounted. The units are available in four models; sizes of one-half and two cubic feet and temperature ranges of −100° F. to +600° F. and −300° F. to +600° F. The FT 1.5 series is mechanically refrigerated with a temperature range of −100° F. to +350° F.

WRITE FOR FREE BROCHURES



Reliable Test Equipment Since 1932

MISSIMERS
INCORPORATED
3741 SAN FERNANDO ROAD / GLENDALE, CALIF. 91204
Phone: (213) [illegible]

Circle No. 8 on Subscriber Service Card

Remote Control Console

A high-precision voice and telegraphy receiver with remote control console is now available from RACAL Communications, Inc. Designed for use in long-distance communications networks, the RTA-191 is a multi-unit receiving terminal that covers the range from 2 to 30 mc and is suitable for SSB (upper or lower), ISB, normal DSB and CW operation. The terminal employs a RACAL MA-250 decade frequency generator to assure stable and accurate frequency setting. A central frequency standard can be used to control a number of receivers, or individual standards can be used with each.

Circle No. 152 on Subscriber Service Card

Single Crystal

Single crystal materials of CalVanBIG, a low-saturation-magnetization garnet material, are available from the Airtron division of Litton Industries.

The material, with the formula $(\mathrm{Bi}_{3-2x}\mathrm{Ca}_{2x})\ [\mathrm{Fe}_2]\ (\mathrm{Fe}_{3-x}\mathrm{Vx})\ \mathrm{O}_{12}$, is offered in the form of spheres, rods, discs and special shapes. Saturation magnetization ($4\pi M/s$) is approximately 250-450 gauss, and linewidth is 1.5 to 3 oersteds, nominal. Prices for small quantities of spheres of this material range from $110 (20-35 mils dia.) to $180 (55-75 mils dia.). Delivery of spheres is from stock to two weeks, and delivery of special shapes will be quoted on receipt of customer requirements.

Circle No. 153 on Subscriber Service Card

10-Watt RF Power Amplifier

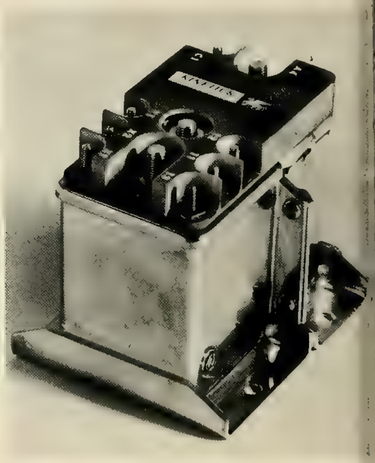
A solid state power amplifier capable of providing a full 10 watts of output RF power with an efficiency of 45% under all specified environmental conditions is available from Leach Corp. Designated model TA-1000, the amplifier operates on the standard frequency range of 216 mc to 260 mc. It features solid-state circuit design advancements and can be driven by standard one-to-four-watt telemetry transmitters, making it easy to integrate into most telemetry systems. Reliable operation is achieved in a case temperature environment of −20°C to 85°C. This wide range of application is obtained through use of transistors with special thermal characteristics. Improved heat sinking methods are also used to allow adequate transfer of internally generated heat.

Circle No. 154 on Subscriber Service Card

Current-Sensing Switch

Two current-sensing, motor-driven switches have been developed by Kinetics for use aboard manned spacecraft. The M945-1 sensor-switch provides protection for nominal 28v d-c power sources such as fuel cells or batteries. Protection in the forward current direction is provided with an inverse time "trip" characteristic over the range of 75 to 1,000 amps.

Reverse currents in excess of 10 amps will also cause the switch to open. The M968-1 provides inverse time "trip" protection for 28v d-c motor loads with full load ratings of 40 to 50 amps and inrush currents up to 400 amps. Load current less than 6 amps will also cause the switch to open to remove an open-circuit motor load from the system. The continuous total power consumption of either solid-state sensor and switch combination is less than 0.5 watts at 28v dc. The motor-driven switch portion requires no holding current after transfer. In addition to the main contacts, indicating and remote manual control circuits are also provided. Environmental operating specifications include −65°F to +200°F temperature range; 15-g sinusoidal plus 0.13-g^2/cps random, 5-2,000 cps, complex vibration; and 50-g shock.



Circle No. 155 on Subscriber Service Card

Miniature Audio Amplifier

A solid-state miniature high fidelity audio instrumentation amplifier is available from REO Div. of Spectra-Strip Wire and Cable Corp.

Designed for use at medium-level application, the Model A002 provides single, dual or multiple input and output impedances, which can be varied at the user's option. The unit incorporates internal voltage regulation independent of the source.

Brief specifications include: input 0.3v rms; output 0.5 rms; gain 10; frequency response, 60 cps to 25 kc ± 1 db. The unit is potted and hermetically sealed. It meets mil specs for environmental factors.

Circle No. 156 on Subscriber Service Card

Diode Switch

Antenna & Radome Research Asociates, Inc., has developed an X-band olid-state diode switch with OSM-type ias and RF connectors.

The device is designed to military pecifications and will meet or exceed he following characteristics: frequency ange, 8,400 to 9,400 mc; typical minimum isolation, 20 db; typical maximum nsertion loss, 2 db; RF power, 4w average, 150w peak, 0.001 duty cycle; witching time, 10 nsecs; operating temperature range, —55° to 85°C.

Circle No. 157 on Subscriber Service Card

Low-Level Digital Logger

The 7000A series data logging sysems, available from Cimron Corp., eatures 600 points of input scan and a uarded differential, full five-digit digital oltmeter with preamplifier. Voltage anges are from 10mv full scale (0.1 nicrovolt resolution) to 1,000v full cale. Recorded data is provided in the orm of printed paper tape, with a ariety of other output options available.

By simply changing input plug-in acessories, the system may be used for -c or resistance measurements.

Circle No. 158 on Subscriber Service Card

Pancake Synchro

Sunbeam Electronics, John Oster Mfg. Co. has extended its component ine to include a 400-cps, size 26 pancake synchro. The initial configuration or this unit is a high-impedance conrol transformer with an accuracy of even minutes and an output impedance of 40,000 ohms. The phase shift is 2° with an output of 22.5v. The size 26 unit is designed to operate over a temperature range from —55° C to 150° C.

Circle No. 159 on Subscriber Service Card

Gallium Arsenide Diodes

Three gallium arsenide light-emiting diodes, said to have an order of magnitude higher infrared output at room temperature than previous models, are being marketed by General Electric Co.'s Semiconductor Products Dept.

One Model, the LED-10, has a minimum continuous output at room temperature of 100 mw with a 300-mw ypical output. Input is 100 ma at 9,000 Angstroms wave length and 210 Angstroms spectral bandwidth. Pulsed output at —77°K (liquid nitrogen) is up to 3 watts (8,450 Å wavelength; 170 Å spectral bandwidth).

The diodes feature a modulation capability exceeding 10 mc. Temperature range is —77°K to 125°C. Model LED-11 features a removable lens cap that permits designers to supply their own optics. LED-9 is a lower output version of the LED-10.

Circle No. 160 on Subscriber Service Card

Portable Frequency Standard

Anadex Instruments, Inc., has developed a portable, crystal-controlled frequency standard with a range of 0.5 cps to 600 kc.

FREQUENCY
MULTIPLIER
OUTPUT
CPS
AMPLITUDE

The Model CU-2 has an accuracy of 0.0005%. Frequency selection is by means of a 13-positioner selector switch and a four-decade multiplier switch. Output voltage is a square wave with amplitude adjustable to 20v peak-to-peak. Power cycle is 115v ac, 60 cps.

Circle No. 161 on Subscriber Service Card

Forty-Contact Terminal

Methode Electronics, Inc., is marketing a 40-contact terminal block, Model TB-840DS, designed for wave soldering to large printed circuit boards. Designed for the *Minuteman* missile program, the Methode terminal block is expected to find use in power supply hook-up in computers, and other data acquisition and transmission equipment. The Model TB-840DS has 40 tapped hole contacts, which accept #4-40 screws. The contact is terminated in a 0.031 in. dia. x 0.150 in. long pin, suitable for insertion into a printed circuit board. Mounting is accomplished through three #4-40 tapped stainless steel inserts.

Circle No. 162 on Subscriber Service Card

Materials Indentifier

A test instrument for positive identification of materials for component lead welding has been announced by Apollo Instruments, Inc.

The battery-operated, portable unit permits identification of five diameters of eight materials most commonly used in welded construction techniques. Up to 6,000 leads can be checked in an eight-hour shift. Using a color coded scale, the comparator provides both chemical and physical property readings.

Circle No. 163 on Subscriber Service Card

$295.
ENVIRONMENTAL TEST CHAMBER

THE "SATELLITE"
Model XLH-0.5-LC

✓ Check these quality features:

- Temperature Range —100°F to + 350°F
- Temperature Control Accuracy, ±2°F
- Stainless Steel Interior — 10"H x 8"W x 11"D
- Fully Insulated — Fiberglas
- Forced Air Circulation
- Removable Door With Silicone Gasket
- Operable on Bench or in Standard 19" Relay Rack

LOWEST PRICE ON EARTH

ORDER YOUR LOW-COST "SATELLITE" TODAY!

Delivery from stock

Associated Testing Laboratories, Inc.
MANUFACTURING DIVISION
135 Route 46, Wayne, N. J. • Phone: (201) 256-2800

Circle No. 9 on Subscriber Service Card

AEROSPACE ENGINEERS

Give your career a big lift at Douglas!

Rapidly expanding activities at Douglas relating to huge new aircraft programs have created outstanding career openings. Work areas include a great new development program on what will be the biggest jet transport in the world and a variety of exciting new military and commercial projects extending through the next decade and beyond. Division between military and commercial is approximately 50-50.

We are seeking aircraft engineers with BS or advanced degrees with experience in any of the following: Stress Analysis; Load Analysis; Dynamic Analysis; Electrical Design; Structures Design; Aerodynamics; Power Plant — Thermo-Mechanical; Flight Test Instrumentation; Flight Test Data Analysis; Reliability; Advanced Systems Engineering. Openings include a number of senior positions.

For full information, please send your resume to Mr. C. A. Carrico, Professional Employment, Douglas Aircraft Company, 3851 Lakewood Boulevard, Long Beach, California. Douglas is an equal opportunity employer.

DOUGLAS
AIRCRAFT DIVISION

The Industry Week

Mergers and Acquisitions

Varian Associates, Palo Alto, Calif., has announced negotiations toward the acquisition of Mikros, Inc., a subsidiary of Electro Scientific Industries. Mikros is a Portland, Ore., firm specializing in the vacuum and electron microscope fields. . . . *Radio Corp. of America and Prentice-Hall, Inc., have announced that negotiations are underway for a merger of the two firms. The New York City companies will ask for approval of respective boards of directors and stockholders at a later date. If successfully concluded, the merger would provide that each share of P-H common stock presently outstanding would be exchanged for ½ share of RCA common stock and 3/10 share of a new $1.75 cumulative convertible RCA preferred stock to be issued.* . . . William C. Allen Corp., Washington, D.C., has acquired Photo Magnetic Systems, Silver Spring, Md. PMS is an R&D firm specializing in areas of information storage and retrieval, data displays and optical character recognition. Allen Corp. is a management consulting firm. . . . *Alpha Industries, Inc., has been formed in Newton, Mass., by the merger of three area microwave component companies. The three firms are Alpha Microwave, Inc., Newton, Mass.; Micro-Optics, Inc., Waltham, Mass.; and Microwave Technology, Inc., Waltham, Mass. They will be operated as wholly owned subsidiaries of the parent company. George S. Kariotis, former president of Alpha Microwave, will head the new company.* . . . Data Products Corp., Culver City, Calif., has announced plans to acquire Data Processing Systems, a software firm located in Los Angeles and Palo Alto. It will be operated as part of Data Products' subsidiary, Informatics, Inc. . . . *Tektrol, Inc., Arcadia, Calif., has purchased manufacturing rights to a line of power supply products manufactured by Power Devices, Inc.* . . . Consolidated Electrodynamics Corp., Pasadena, Calif., has purchased a line of emission spectrometers from Research & Control Instruments, Inc., a subsidiary of Epsco, Inc., Westwood, Mass. The product line will be integrated into CEC's Analytical & Control Div.

Missile/Space Activities

F&M Scientific Corp., Avondale, Pa., has formed a commercial analytical services group to provide consulting and analytical services on a fee basis. The group will operate within the F&M applications laboratory. . . . *Louis Allis Co., Milwaukee, has formed a Power Electronics Div., Greendale, Wis. The division, which was formerly the Greendale Research Center, will emphasize solid-state power electronics employing digital control techniques.* . . . Armstrong Cork Co. has united three of its former divisions into the Building, Industry and Defense Products Operations in Lancaster, Pa. The company has announced plans to concentrate on the ablation materials market and establish itself as a source for artificial dielectric media. . . . *Stockholders of Geophysics Corp. of America will meet Jan. 20 to vote on a proposed name change to GCA Corp. Creation of a class of one million shares of preferred stock for use in acquiring other companies will also be considered at the corporation's annual meeting in Boston.* . . . Park Electrochemical Sales Co., Inc., has been formed in New York City to market all industrial products manufactured by Park Electrochemical Corp.

International

Boeing Co., Seattle, and Boelkow Entwicklungen KG of Germany have announced an agreement in which Boeing will acquire a minority equity interest in the assets and business of the German firm. The firm's status will be changed from a limited partnership to a limited liability and the name will be changed to Boelkow GmbH. Present development and production areas of the firm include electronics and computer equipment, tactical guided missiles, aircraft development, helicopter systems research, space satellites and boosters. . . . *Edgerton, Germeshausen & Grier, Inc., Boston, has named Swift & Co. Pty., Ltd., as product representative in Australia. Swift is located in Ashfield, N.S.W.* . . . Super-Temp Corp., Santa Fe Springs, Calif., producer of high-temperature metals and materials, has named Societe Le Carbone-Lorraine, Paris, France, to provide European marketing and technical assistance for the company.

New Facilities

Nuclear Fuel Services, Inc., a subsidiary of W. R. Grace & Co., Baltimore, has completed construction of an enriched uranium oxide plant at Erwin, Tenn. The new facility is expected to increase the firm's annual production capacity by a factor of five. It replaces three smaller producing plants at the Erwin location. . . . *Data-Control Systems, Inc., Danbury, Conn., has leased a 12,000-sq.-ft. building for its Research & Engineering Dept. The firm produces research instrumentation components and systems.* . . . Defense Systems Div. of Bunker-Ramo Corp., Canoga Park, Calif., has opened a regional office in Dayton, Ohio. J. J. Hooper is in charge of the new office. The division is presently conducting several research programs for Wright-Patterson AFB. . . . *Electronic Associates, Inc., Long Branch, N.Y., has established a district sales office in Cleveland.*

Company Representatives

Korad Corp., Santa Monica, Calif., manufacturer of laser devices, has named Murphy & Cota, Winston-Salem, N.C., sales representatives in Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, Tennessee and parts of Louisiana. . . . *Adams-Russell Co., Inc., Waltham, Mass., has appointed Forsberg Sales, Inc., Brockton, Mass., exclusive sales representative in six New England states. Forsberg will market the firm's line of broadband RF communications components.*

contracts and procurements

AWARDS

AIR FORCE

$26,683,424—**Westinghouse Electric Corp.**, Baltimore, for the production of low-frequency communications sets.

$1,746,175—**Electronic Specialty Co.**, Los Angeles, for production of automatic tracking telemetry antennas.

$1,072,549—**Hazeltine Corp.**, Little Neck, N.Y., for communications equipment.

$101,500—**Avco Corp.**, Avco-Everett Research Lab., Everett, Mass., for development of a magnetohydrodynamic generator burner system.

ARMY

$2,607,245—**Avco Corp.**, Cincinnati, for operation of missile tracking and instrumentation radars.

$1,793,390—**Westinghouse Electric Corp.**, Baltimore, for development of special UHF-VHF equipment.

$1,342,628—**Smith and Sapp Construction Co.**, Orlando, Fla., to construct an *Apollo* spacecraft training building for NASA lunar astronauts.

$1,302,134—**Intercontinental Manufacturing Co.**, Garland, Tex., for first and second-stage rocket motor cases for *Pershing* missiles.

$1,134,456—**Thiokol Chemical Corp.**, Bristol, Pa., for rocket motors.

$854,128—**Julian Evans and Associates, Inc.**, Titusville, Fla., for construction of six camera sites and four weather stations to provide data for launches from Cape Kennedy and the Merritt Island, Fla., spaceport.

$654,483—**Radio Corp. of America**, Communications Systems Div., Camden, N.J., for a classified program.

$542,597—**Akwa-Downey Construction Co.**, Milwaukee, Wis., for an ordnance storage facility for explosive devices used on the *Saturn V*.

$435,000—**American Electronic Laboratories, Inc.**, Colmar, Pa., for pulse analyzers, AN/ULA-2.

$63,758—**Raytheon Co.**, Andover, Mass., for emergency requirements for NATO-*Hawk*.

$60,730—**Nat Harrison Associates, Inc.**, Miami, Fla., for construction of a 200-ft. radar antenna tower on Merritt Island.

$40,266—**Raytheon Co.**, Andover, Mass., for replenishment repair parts for the *Hawk* missile system.

$39,200—**Voigt Construction Co.**, Chuluota, Fla., for alterations to the Central Control Building at Cape Kennedy for the *Titan III* program.

NAVY

$19,432,798—**Lockheed Aircraft Corp.**, Sunnyvale, Calif., for engineering work on *Polaris* missiles.

$3,712,956—**Philco Corp.**, Philadelphia, for production of *Sidewinder* missiles.

$2,602,530—**General Electric Co.**, Syracuse, N.Y., for modification work on a sonar system.

$2,500,000—**Bendix Corp.**, Mishawaka, Ind., for continued work on the *Talos* air defense missile program.

$1,627,000—**Raytheon Co.**, Lexington, Mass., for data converters for use with radar on *Tartar* air defense missiles.

$1,322,503—**Ling-Temco-Vought, Inc.**, Greenville, Tex., for classified work on unspecified aircraft.

$1,210,125—**Maxson Electronics Corp.**, New York, for supersonic-speed targets for Navy missiles.

$167,000—**Bissett-Berman Corp.**, Santa Monica, Calif., to design, fabricate and install a deep-moored vertical hydrophone array with a telemetry link to shore stations.

NASA

$1,572,326—**Monitor Systems, Inc.**, Ft. Washington, Pa., for two telemetry systems to be installed at the Merritt Island Launch Area. Two digital telemetry systems will be fabricated and will be used as intermediate data converters and processors during *Apollo/Saturn V* launches.

$507,318—**Honeywell Inc.**, Minneapolis, for *Centaur* guidance ground support equipment.

$311,474—**Honeywell Inc.**, Aeronautical Div., St. Petersburg, Fla., for definitization of letter contract for *Centaur* GG177 accelerometer study and evaluation program.

$162,973—**Radio Corp. of America**, Astro-Electronics Div., Highstown, N.J., for automatic picture-taking system.

$96,450—**TRW/Space Technology Laboratories**, Redondo Beach, Calif., for research on ion beam diagnostics.

Control Technology, Inc., Long Beach, Calif., for a study contract to provide an error analysis of hybrid computer simulation of six-degree-of-freedom equations of motion (amount undisclosed).

Electro-Mechanical Research Inc., Sarasota, Fla., for FM telemetry equipment for two Mobile Launcher Vibration Data Acquisition Systems (amount undisclosed).

INDUSTRY

$2,300,000—**Lear Siegler, Inc.**, Santa Monica, Calif., from **Grumman Aircraft Engineering Corp.**, Bethpage, N.Y., for flight attitude indicators for the Lunar Excursion Module of Project *Apollo*.

$1,217,655—**Brown Engineering Co., Inc.**, Huntsville, Ala., from **Catalytic Construction Co.**, Philadelphia, for the fabrication, installation, cleaning, calibration and check-out of complete instrumentation, pneumatics and electrical systems for the *Apollo/Saturn V* launch vehicle.

$1,049,031—**Morison-Knudsen, Perini Corp., and Paul Hardeman, Inc.**, South Gate, Calif., from **Catalytic Construction Co.**, Philadelphia, for the fabrication, installation, cleaning and testing of the complete LOX, LH2, RP-1 and pad area pneumatic system piping and equipment for the *Apollo/Saturn V* launch vehicle.

$400,000—**Space Corp.**, Garland, Tex., from **The Boeing Co.**, Seattle, for manufacturing electronic, alignment and mechanical maintenance truck vans and assembling them on government-furnished chassis—in connection with Project *Minuteman*.

$290,000—**Saginaw Products Corp.**, Saginaw, Mich., from **The Boeing Co.**, Seattle, to supply components used in the *Minuteman II* ICBM launch control area.

$264,650—**Honeywell Inc.**, Minneapolis, from **Ryan Aeronautical Co.**, San Diego, Calif., for 50 low-altitude radar altimeters to be installed on *Firebee* drones.

Decision Systems, Inc., Teaneck, N.J., from **Electro-Mechanical Research, Inc.**, Advanced Scientific Instruments Div., Minneapolis, to write the diagnostic program for the new ASI 6020, a medium-scale digital computer for scientific, engineering and on-line systems applications (amount undisclosed).

ARMS CONTROL AND DISARMAMENT AGENCY

$53,739—**Denver Research Institute of the University of Denver**, Denver, Colo., to prepare a series of industrial conversion case studies.

$12,587—**Martin Marietta Corp.**, Denver, for a study to obtain information on the re-employment experience of Martin Co. workers whose jobs have been terminated at the Denver plant as a result of changes in missile procurement.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Directorate of R&D Procurement
Systems Engineering Group
Wright-Patterson AFB, Ohio 45433

Negotiations will be conducted with TRG, Inc., Melville, N.Y., for optical radar testing on a continuation of Contract AF 33(615)-2063. For information only; RFP not available.

National Aeronautics and Space Administration
Marshall Space Flight Center
Huntsville, Alabama 35812

NASA has issued RFQ's on the development of techniques for measuring thermal diffusivity, Proposals due 1/17/65.

Who keeps things in order

when missiles, ships, aircraft and mobile ground equipment have to be in the right place at the right time for a crucial launch?

It's a demanding assignment, one that leaves no room for anything but top level judgment and careful planning of the highest order. At Patrick Air Force Base, Florida, this critical decision post is manned by a Technical Programs Director, a civilian member of the team serving the Air Force Systems Command's National Range Division. The position is now open. A desirable background is four years of broad experience in a technical or scientific field, (e.g. Electronics). Three years of specialized experience in the electronics and aeronautical engineering disciplines. Candidates must possess an extensive background in test Range Programs and Operation. An education through college level in an engineering field with a Masters or PhD degree in the engineering or scientific areas is desirable, plus a strong background in R&D Administration. The position carries full benefits of the Career Civil Service. Send resumes or Application for Federal Employment (SF-57), in full professional confidence to:

AFETR (ETBPC-1)
ATTN: Mr. Leon Clark, Dept. MR-1-4
Patrick Air Force Base, Florida 32925
An equal opportunity employer

All the Missile/Space News When It's NEWS!

. . . in the missile/space daily

1001 Vermont Ave., N.W., Washington, D.C., 20005 • STerling 3-5400 • TWX: 202-965-0566

William J. Coughlin, Editorial Director
William D. Hall, Editor
Wayne W. Parrish, President
James W. Claar, Publisher

Published daily, except Saturdays, Sundays and Holidays by **American Aviation Publications, Inc.**, in Washington.
SUBSCRIPTION RATE: $20 a month, $110 for six months, $220 a year, postpaid. Quantity and deferred mailing rates on request.
APPLICATION FOR REPRODUCTION of material contained herein should be made to the editors.

MISSILE/SPACE DAILY is the executive's primary source of latest developments in the multi-billion dollar missile/space and defense industries. It is a factual news service designed to bring you accurate and comprehensive industrial and governmental reports every twenty-four hours.

MISSILE/SPACE DAILY provides you with in-depth industry news coverage available in no other daily publication . . . including current reports of all significant developments in the United States and International missile/space and defense industries.

On your desk at 9 a.m. each business day, MISSILE/SPACE DAILY brings you the latest management and technical reports concerning missile/space:

Contract Awards . . . Budgets . . . Missile/Space Financial Activity . . .
Space Systems . . . Subsystems . . . Ground Support Equipment . . .
Technological Developments . . . Electronics . . . Propulsion and
Propellants . . . Research and Development . . . Industry Trends

There is no information lag. Each day the DAILY's expert staff covers the missile/space news as it develops in key cities throughout the world . . .

Washington . . . New York . . . Boston . . . Houston . . . Cape Kennedy . . .
Los Angeles . . . Huntsville . . . Seattle . . . Paris . . . London . . . Tokyo

As a MISSILE/SPACE DAILY reader, you will benefit from the services of a "personal staff" filing industry reports from . . .

The Department of Defense . . . The National Aeronautics and Space Administration . . .
Atomic Energy Commission . . . Congress . . . Prime Manufacturers . . . Sub-Contractors

The rapidly-changing missile/space industry demands that you be well-informed. Keep up-to-date with latest developments and trends in missile/space and defense . . . Read MISSILE/SPACE DAILY.

For a limited time we are offering a special Introductory Offer of a full month's service of the MISSILE/SPACE DAILY for $10.00, a 50% saving. Return the coupon below today for immediate service.

INTRODUCTORY SUBSCRIPTION OFFER — $10.00 FOR COMPLETE MONTH'S SERVICE

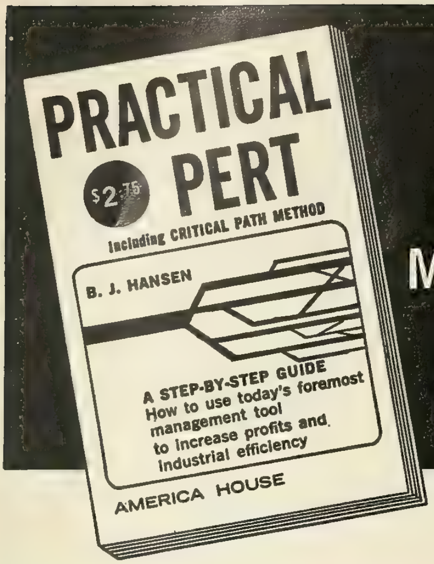
Yes, I accept your Introductory Subscription offer to try the Missile/Space DAILY for one month at $10.00, a 50% saving. ☐

Name____________________ Company____________________

Address____
Street City Zone State

Regular Rates: ☐ 1 month $20 ☐ 6 months $110 ☐ 1 year $220
Bill Me ☐ Bill Company ☐

Mail coupon to: MISSILE/SPACE DAILY, 1001 Vermont Ave., N.W., Washington, D. C. 20005


PRACTICAL PERT
$2.75
Including CRITICAL PATH METHOD
B. J. HANSEN
A STEP-BY-STEP GUIDE
How to use today's foremost management tool to increase profits and industrial efficiency
AMERICA HOUSE

FOR ALL LEVELS OF MANAGEMENT

offered for the first time

$2.75

by B. J. HANSEN
(member of the original Polaris-PERT Team)

You get the complete **PERT** system and, for the first time, a **PERT** technique showing you how to predict and monitor profit on a continuing bi-weekly cycle.

Chapter XI, "Profit **PERT** and Incentives," brings you the Martin Company case history showing how the Titan III **PERT**-profit system works: In the words of Secretary of Defense Robert McNamara, "(Titan III) is probably the best managed contract we have, and it is the best managed almost entirely because of the tremendous incentive given to that contractor in the form of potential profit increases to hold his costs down."

PRACTICAL PERT tells how and when to meet contract obligations, how to keep programs on schedule, how to win highest incentive fees. **PERT**, developed for the nation's defense programs, can be applied to management operations to monitor profit as well as cost, time and performance in the fields of construction, chemical processing, manufacturing . . . and wherever complex systems are involved.

PRACTICAL PERT contents

I INTRODUCTION TO PERT
II THE ABC'S OF PERT
III PERT & TIME
IV HOW PERT PLANS
V HOW PERT CONTROLS
VI BUILDING PERT
VII WHAT IS NETWORKING
VIII REFINING THE NETWORK
IX MEASURING MANAGEMENT RISK
X PERT & COST
XI PERT COSTS & COMPUTERS
XII PROFIT PERT & INCENTIVES
XIII PERT DATA DISPLAY

AMERICA HOUSE
1001 Vermont Avenue, N.W., Washington, D.C. 20005

Send Me ☐ Copies of Practical Pert $2.75 .25c Handling $3.00

☐ Check Enclosed ☐ Bill Me

Name________ Job/Title________

Address________ City________

Zip Code________ State________ Co. Name________

—names in the news—

Harold S. Geneen: Elected to the po of chairman of the board of Internation Telephone and Telegraph Corp., New Yor City. He has been president and chie executive officer since June 1959, and wi continue in these capacities. **Ted B. Wes fall,** a vice president and group executiv since October, 1960, has been promoted t executive vice president.

O. John Hayles: Named vice presiden and general manager for the central operation of Sylvania Electronic Systems, a division of Sylvania Electric Products Inc.

Dr. Adolph L. Antonio: Elected chairman of the board of Space-General Corp El Monte, Calif. He will also oversee corporation operations in his new role as grou vice president of Aerojet-General Corp SGC's parent company.

Dr. William F. Ballhaus: Elected president of Beckman Instruments, Inc., Fullerton, Calif., and a member of the company' board of directors. He was formerly executive vice president and will remain a director of the Northrop Corp. **Arnold O. Beckman,** former president and founder o Beckman Instruments, will assume th newly-created position of chairman of th board.

Dr. Walter B. LaBerge: Appointed director of engineering and resarch for th defense, space and industrial electronic divisions of Philco Corp. He replaces Dr S. Dean Wanlass, who has resigned.

Dr. J. C. Warner: Elected chairman o the board of the Nuclear Science & Engineering Corp., Pittsburgh. He will retir as president of Carnegie Institute of Technology Jan. 31.

Edward C. Nezbeda: Appointed a vic president of Grumman Aircraft Engineering Corp., along with **William M. Zarkowsky,** who was also appointed a vice president.

Dr. Gordon K. Teal: Appointed director of the Institute for Materials Research National Bureau of Standards. He is on of the pioneers of the transistor field an is presently assistant vice president and international technical director for Texa Instruments Inc., Dallas. He is acceptin the government responsibility for approximately two years.

M/R erred in the "Names in the News" section of the Dec. 14 issue (p. 44). The item correctly announced that **Clarence J. Woodard,** president and director of The Rucker Co., Oakland, Calif., had been elected to the board of directors of Systron-Donner Corp., Concord, Calif. The error was in identifying The Rucker Co. as a subsidiary of Systron-Donner, which it is not.

Advertisers' Index

ASSOCIATED TESTING LABORATORIES, INC. 39
Agency—Richard Steensma

AUTONETICS, A DIVISION OF NORTH AMERICAN AVIATION, INC. 4
Agency—Batten, Barton, Durstine & Osborn, Inc.

AVCO RESEARCH & ADVANCED DEVELOPMENT, A DIV. OF AVCO CORP. 48
Agency—Benton & Bowles, Inc.

BEECH AIRCRAFT CORP. 2, 3
Agency—Bruce B. Brewer & Co.

BOEING CO., THE 7
Agency—Campbell-Ewald Co.

CONIC CORP. 35
Agency—Teawell, Inc.

DEFENSE ELECTRONICS, INC. 8
Agency—Compton Jones Associates

DOUGLAS AIRCRAFT CO., INC. 40
Agency—J. Walter Thompson Co.

GRAND BAHAMA PROPERTIES, LTD. .. 6
Agency—Arthur R. Mogge, Inc.

HUGHES AIRCRAFT CO. 47
Agency—Foote, Cone & Belding

MCDONNELL AIRCRAFT CORP. 18
Agency—John Patrick Starrs, Inc.

MISSIMERS INC. 38
Agency—Ad Lab Adv.

NORTHROP CORP. 24, 25
Agency—Doyle, Dane, Bernbach, Inc.

PAN AMERICAN WORLD AIRWAYS, INC., GUIDED MISSILES RANGE DIV.. 36
Agency—Deutsch & Shea, Inc.

PARKER SEAL CO. 27
Agency—The Lester Co.

SCIENTIFIC-ATLANTA, INC. 11
Agency—Bohm-King Associates

UNITED STATES AIR FORCE—AFSC/AFLC, JOINT PROFESSIONAL PLACEMENT OFFICE 42
Agency—Gaynor & Ducas, Inc.

—when and where—

JANUARY

Eleventh National Symposium on Reliability and Quality Control, sponsored by the American Society for Quality Control and the Institute of Electrical and Electronics Engineers, Fountainebleau Hotel, Miami Beach, Jan. 12-14.

The Advanced Incentive Contracting Seminar, sponsored by the National Defense Education Institute, Houston, Jan. 13-15.

1965 Government-Industry Forum, sponsored by the National Electrical Manufacturers Assn., New Orleans, Jan. 18-19.

International Symposium on Solar Radiation Simulation, sponsored by the Institute of Environmental Sciences and the ASTM, International Hotel, Los Angeles, Jan. 18-20.

Conference on Quantitative Analysis and and Evaluation for Production Activities, sponsored by Purdue University, Purdue University, Lafayette, Ind., Jan., 20-22.

Winter Meeting of the National Society of Professional Engineers, Jung Hotel, New Orleans, Jan. 20-23.

"The Case for Impure Research," lecture sponsored by the Advanced Research Projects Agency, The Pentagon, Washington, D.C., Jan. 21.

National Symposium on Hydrocarbon Analysis, sponsored by the ASTM, Sheraton-Lincoln Hotel, Houston, Tex., Jan. 22-23.

Symposium on Fundamental Phenomena in the Material Sciences, sponsored by the Ilikon Corp., Sheraton Plaza Hotel, Boston, Jan. 25-26.

Second Annual Aerospace Sciences Meeting, sponsored by the AIAA, New York Hilton, New York City, Jan. 25-27.

Joint Annual Meeting of the American Mathematical Society and the Mathematical Assn. of America, Univ. of Colorado, Denver, Jan. 25-30.

Second Winter Power Meeting of the Institute of Electrical and Electronics Engineers, Statler-Hilton Hotel, New York City, Jan. 31-Feb. 5.

FEBRUARY

Reinforced Plastics Division Conference sponsored by the Society of the Plastics Industry, Edgewater Beach Hotel, Chicago, Feb. 2-4.

Winter Convention on Military Electronics, sponsored by the Institute of Electrical and Electronics Engineers, Ambassador Hotel, Los Angeles, Feb. 3-5.

Unmanned Exploration of the Solar System, sponsored by the American Astronautical Society, the American Astronomical Society, American Geophysical Union, American Institute of Biological Sciences, IEEE and AIAA, Denver Hilton Hotel, Denver, Feb. 8-10.

Fifth National Symposium of the Society for Information Display, Miramar Hotel, Santa Monica, Calif., Feb. 25-26.

let us move with you!

Six Weeks Is Required To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, **if possible, the address label from your last issue . . .** include your postal zone or zip number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

◆ ◆ ◆

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Geneva, Switzerland—10 Rue Grenus; Geneva 321044

Paris, France—11 Rue Condorcet; TRU 15-39

editorial . . .

The Threat

SECRETARY OF DEFENSE Robert McNamara has indicated that he will not seek funds in the Fiscal 1966 budget for a *Nike-X* pre-production program. Further, the Secretary has made clear his feeling that deployment of the anti-missile missile system does not make sense unless it is accompanied by an adequate civil defense shelter program.

We quite agree with him about the shelters. Any nuclear exchange involving *Nike-X* would result in an unacceptably high fatality rate among an unprotected civilian populace, to say nothing of the effects wrought by those incoming warheads which escaped interception.

Shelters for civilians therefore are a must for any credible missile defense. To date, there has been no adequate civil defense program—although a step was made in the right direction when authority over the program was transferred to the Pentagon.

Whether this Administration now is willing to back an all-out civil defense effort is open to question, however. For one thing, the thought of alarming the Great Society at its very inception with strong support, both moral and financial, for blast and fallout shelters is a distasteful one to President Johnson. Also being taken into consideration is the question of whether initiation of such a program might not be taken by the Soviet leadership as an indication of a more belligerent policy by this country. There are those who strongly believe that it would and who watch closely for any sign that the Russians are undertaking a wide-scale shelter program. So far they have not.

The temptation in these circumstances is to do nothing and avoid alarming both Americans and Russians. There is also the hope that a continuing *détente* in the Cold War might make the whole unpalatable *Nike-X-cum*-shelter business unnecessary. Just what move the Soviets will make next in the ICBM field also is under close scrutiny, again in the hope that they will do nothing to upset the comfortable offensive superiority now credited to this country by U.S. intelligence.

Unfortunately, the *Nike-X* and fallout shelter decision is one which must be made soon. This is not an area in which we can stand around forever with our option in our hand. If and when an anti-missile defense is needed, it will be needed immediately—not at some future date which will allow time for deployment.

Some comfort has been taken in certain circles from the belief that *Nike-X* is not really important because missile defense can never catch up with missile offense. The just-completed *Nike-X* Threat Analysis Study (see p. 12) sheds some interesting light on this theory. The study indicates that missile offense and defense are much closer to a standoff than many people believe.

The significance of this is considerable. For one thing, it means that a U.S. ballistic missile defense can play an important role in our strategic posture. More important, it means that the door is open for the Soviet Union to undertake an anti-missile defense which can offset our present superiority in strategic missiles.

The Administration belief that the Russians have not done so is indicated by the confident cutback by Secretary McNamara of 200 previously planned *Minuteman* missiles. But the questions remain of whether the Soviets could do so, and whether they could do so without our detecting the initiation of such a large-scale program.

An article in the December issue of *Fortune* by the very able Mr. Charles J. V. Murphy sheds some interesting light on this. Mr. Murphy details the history of the Soviet missile effort, as watched by the Turkish radars and the U-2 aircraft, as well as other intelligence sources.

Although we have detailed much of the history in this magazine as it developed, it is worthwhile noting what Mr. Murphy has to say about Soviet anti-missile defenses: "Meanwhile, there had emerged, too, ominous indications that the Russians had begun to test an anti-missile missile system, a concept that our scientists then held and still hold to be wholly impracticable. Indeed, the R&D center of this enterprise was finally located by a U-2 early in 1960 in Central Siberia, at Sary Shagan, a large community on Lake Balkash, about 400 miles east of the ICBM test establishment at Tyura Tam. It was established that the interception of rockets by other rockets had actually been attempted, with some success, and thereafter in U.S. intelligence calculations account had to be taken of the chance, however improbable, that Soviet technicians might be close to a defense against the ICBM's."

As Mr. Murphy points out, this was in 1960. Dr. Harold Brown, chief of research and engineering in the U.S. defense establishment, acknowledged not long after taking office that the Soviets had a significant lead over the U.S. in this field. There is no reason to suppose the Russian effort has slackened.

THE QUESTION REMAINS: Could the Soviets conceal plans for deployment of an effective anti-ICBM system? With the Russians aware that they are being closely scrutinized by the *Samos* reconnaissance satellites, we find nothing surprising in the theory that a closed society such as the Soviet Union could hide its anti-missile intentions until the last possible moment.

We then would be presented with a *fait accompli* which would offset our vast investment in *Minuteman, Polaris* and *Titan II*.

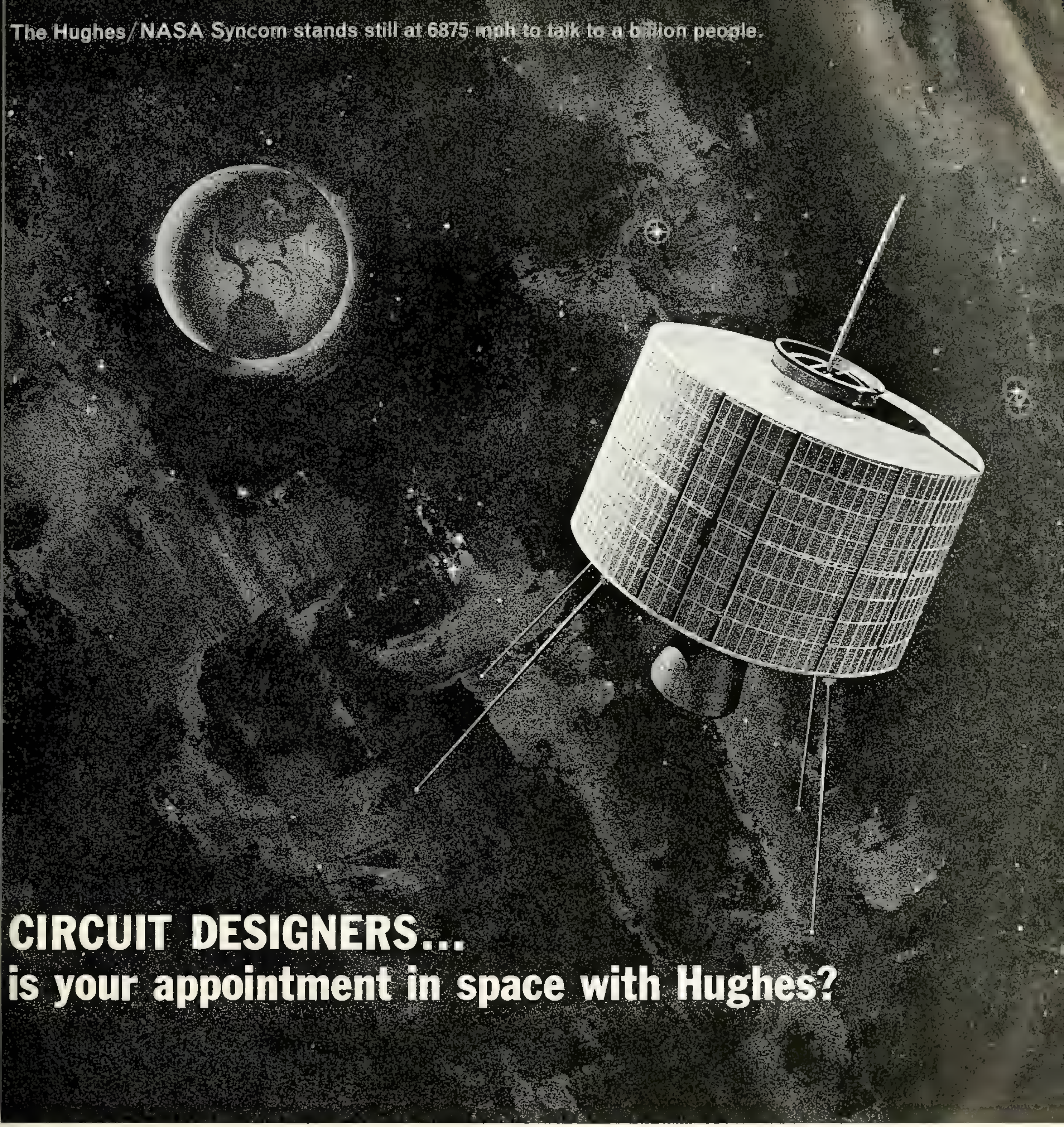
Since it also is possible for the Soviets to carry out the same tactic in regard to new offensive missiles, we believe it necessary to move forward swiftly with both *Nike-X* and a shelter program, no matter how unsettling it may sound.

A top Defense official has something to say about that also. He points out that any anti-missile missile system will kill a percentage of incoming warheads, but not all of them.

"Therefore, the destabilizing argument is just not valid," he says. Missile defense does not upset the mutual deterrence of the two sides.

We therefore hope Secretary McNamara will seek an adequate civil defense program and that Congress will press both for this and for pre-production funds for *Nike-X*.

William J. Coughlin


The Hughes/NASA Syncom stands still at 6875 mph to talk to a billion people.
CIRCUIT DESIGNERS...
is your appointment in space with Hughes?

Today, Hughes is one of the nation's most active aerospace/electronics firms. Projects include: F-111B PHOENIX Guided Missile System, TOW Anti-Tank Missile, SURVEYOR Lunar Spacecraft, SYNCOM, VATE, ARPAT, POLARIS, Hard Point Defense and others.

This vigor will assist the qualified engineers and scientists towards more and better opportunities for both professional and personal growth.

Many immediate openings exist. The engineers selected for these positions will be assigned to the following design tasks: the development of high power airborne radar transmitters, the design of which involves use of the most advanced components; the design of low noise radar receivers using parametric amplifiers; solid state masers and other advanced microwave components; radar data processing circuit design, including range and speed trackers, crystal filter circuitry and a variety of display circuits; high efficiency power supplies for airborne and space electronic systems; telemetering and command circuits for space vehicles, timing, control and display circuits for the Hughes COLIDAR (Coherent Light Detection and Ranging).

If you are interested and believe that you can contribute, make your appointment today.

For immediate consideration,
please airmail your resume to:

Mr. Robert A. Martin
Head of Employment
Hughes Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 1, California

Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS
An equal opportunity employer.

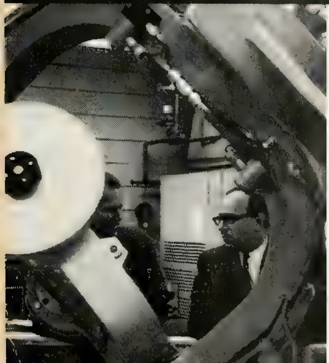
U. S. CITIZENSHIP REQUIRED

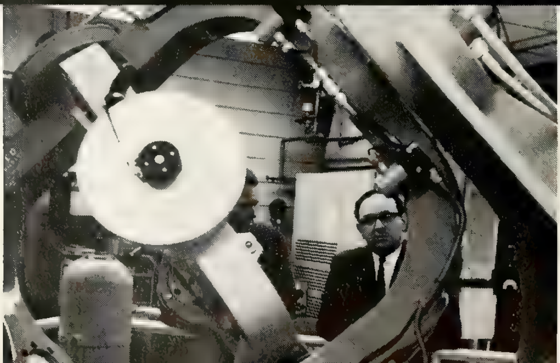
Voyager Guidance & Control:

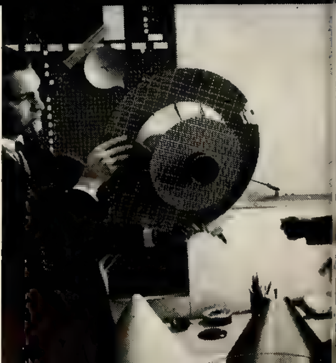
Putting a vehicle in orbit around Mars while landing another on its surface—advanced engineering at Avco/RAD. In a study for NASA's proposed Voyager program, our engineers faced these tough G&C requirements for the spacecraft: maintain proper orientation, with solar cells pointed to the sun; maintain attitude for the release and injection of the lander on a collision course with Mars; keep the communication antenna pointed toward earth; and point the mapping and scanning equipment towards Mars. Using a Canopus star tracker, sun sensor and inertial-attitude reference, we designed G&C systems which would allow the spacecraft to act as a "launching pad" for the lander, and then go into orbit around the planet. Such advanced design is only one of Avco/RAD's capabilities in research, engineering, manufacturing, flight testing, and overall program management. *That's what we mean when we say: Avco/RAD is an integrated research and development organization.*

AVCO/RAD

AVCO CORPORATION/RESEARCH AND ADVANCED DEVELOPMENT DIVISION/WILMINGTON, MASSACHUSETTS







JANUARY 11, [illegible]

nissiles and rockets

M223
JAN [illegible]
HOUSTON PUB
LIBR
Houston, Texas

HE WEEKLY OF ADVANCED TECHNOLOGY

ntenna Test Models at TRW Space Technology Laboratories

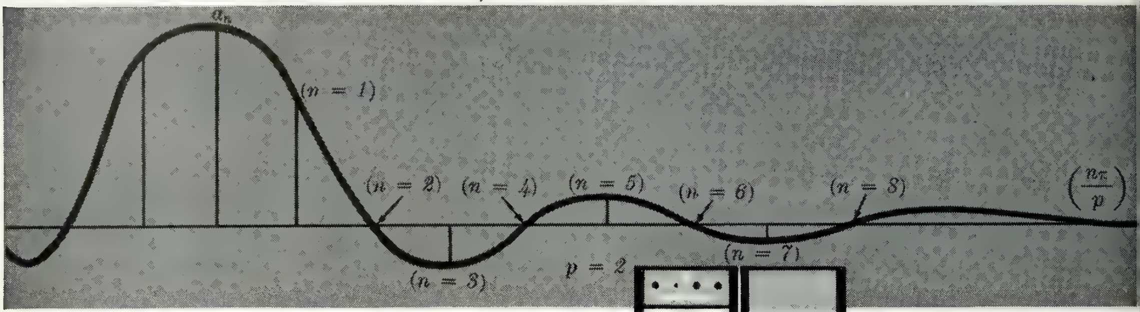
RAM RFP's To Be Sent Out Shortly . . . . . .

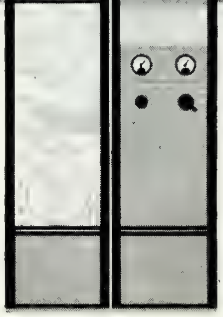
nterest Quickens in Emulsion Potential . .

atest Edition of M/R's Astrolog 21

AN AMERICAN AVIATION PUBLICATION

MATHEMATICIANS, SCIENTISTS & INSTRUMENTATION ENGINEERS / MATHEMATICIANS, SCIEN
TISTS & INSTRUMENTATION ENGINEERS / MATHEMATICIANS, SCIENTISTS & INSTRUMENTATI
ON ENGINEERS / MATHEMATICIANS, SCIENTISTS & INSTRUMENTATION ENGINEERS / MATHEM
ATICIANS, SCIENTISTS & INSTRUMENTATION ENGIN ERS / MATHEMATICIANS
SCIENTISTS & INSTRUMENTATION ENGINEERS / MAT IEMATICIANS, SCIENTIS
TS & INSTRUMENTATION ENGINEERS / MATHEMATIC IANS, SCIENTISTS & IN
STRUMENTATION ENGINEERS / MATHEMATICIANS, SI IENTISTS & INSTRUMEN
TATION ENGINEERS / MATHEMATICIANS, SCIENTISTS & INSTRUMENTATION E





ONLY THE SANGAMO 480 PROVIDES A DELTA TAU

For Auto & Cross-Correlation • Simulates • Buffers Time • Matches Data to Computer Speed

Manipulating time with acquired analog data, the new SANGAMO 480 simplifies many measuring and simulating tasks. It actually plays tricks with time . . . warping, shifting or stretching time to meet given requirements. Applying magnetic tape techniques, it functions as a bridge between incoming analog data and the finished plot or graph.

Auto or Cross-Correlation. Operating with fixed or variable time delays, accuracies of ± 25 microseconds can be maintained. Delays can be achieved from zero to as much as 30 minutes while obtaining a complete correlation result. As an example, wind profiles from a wind tunnel can be correlated to determine whether or not a gyro's capability-limit is sufficient to function successfully in a jet-plane as it moves through certain wind conditions.

Time Delay Range	Time Delay Precision	Bandwidth DC Coupled	Bandwidth AC Coupled
0 to 30 sec.	± 25 μsec.	20 kcps	250 kcps
0 to 120 sec.	± 100 μsec.	5 kcps	60 kcps
0 to 30 min.	± 1000 μsec.	300 cps	7500 cps

Simulation. Artificial aspects may be created electronically with the Sangamo 480, thus saving valuable equipment that would otherwise be destroyed or damaged in actual test. The outcome of many tests or experiments can be predicted with precision. Simulation of Doppler modulation may be obtained by programming the variation in time delay between an input signal and its delay output.

Analog Computer Room Programming. The Sangamo 480 speeds or slows analog data . . . changes the rate at which computing work can be accomplished. Incoming data can be fed to computers in rapid bursts or at a new fixed rate at higher or lower speed. A speed-match is possible to obtain maximum utilization of computing equipment.

Tell us about your problem. The Sangamo 480 may be the answer! Write, wire or phone—address inquiries to: Application Engineering Manager, Electronic Systems Division.

SANGAMO
ELECTRIC COMPANY
P. O. Box 359, Springfield, Illinois 62705
Phone: 217-544-6411

ELECTRONIC SYSTEMS

ES64-2

Circle No. 1 on Subscriber Service Card

PROJECT MERCURY

Dual quad-helix antenna systems for VHF-UHF telemetry-command functions

PROJECT GEMINI

VHF/UHF crossed dipole phased array telemetry tracking systems.

PROJECT GLOTRAC

S, C, X Band, monopulse or conical scan, parabolic antenna tracking systems

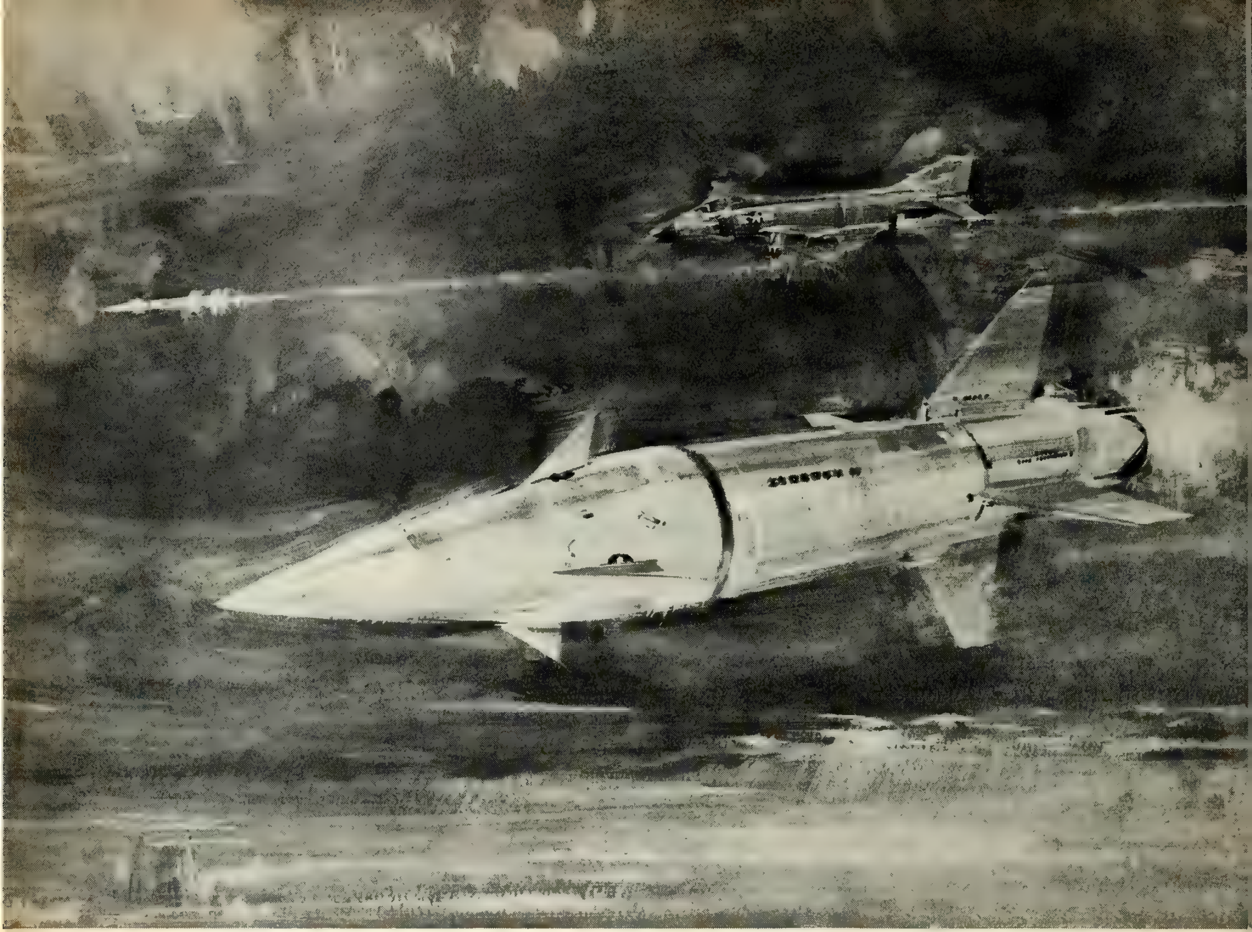
ANTENNA SYSTEMS

Canoga has designed, developed and installed complete antenna tracking systems for use at NASA/DOD instrumentation tracking ranges in support of all the important space programs. Canoga's engineering and manufacturing capability includes the major system components — Antenna, Pedestal, Control System, and Tracking Receiver.

canoga

CANOGA ELECTRONICS CORPORATION 8966 Comanche Ave., Chatsworth, California 91311
Telephone: (213) 341-3010 TWX (213) 341-5399

Circle No. 2 on Subscriber Service Card



From an original painting for CECO by Dick Pfahl

CECO valve selected for BULLPUP Missile

The Bullpup, produced for the Bureau of Naval Weapons by Maxson, is an air-to-surface, Mach 2, guided missile used by the Navy, Marine Corps and Air Force. Guided to its target by radio command from the pilot, directional control of this eleven-foot, operational missile is provided by aerodynamic surfaces actuated by a pneumatic valve engineered and precision-produced by Chandler Evans.

This CECO product joins a distinguished line of pumps, main fuel controls, afterburner controls and other aerospace components in an array of important military aircraft as well as many of the latest and finest missiles and commercial aircraft.

CECO is pleased to be "known by the company its products keep" and by the records those products establish.

Colt Industries **Chandler Evans Control Systems Division**

WEST HARTFORD, CONNECTICUT 06101

GAS TURBINE FUEL CONTROLS/PUMPS • MISSILE CONTROL SYSTEMS/SERVOS • AIRCRAFT/ENGINE ACCESSORIES

Circle No. 3 on Subscriber Service Card

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 2 January 11, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors

Charles D. LaFond .... Electronics
William S. Beller .... Engineering

Associate Editors

Lawrence J. Curran ...... Assistant Managing Editor
Heather M. David .... Space Medicine
Michael Getler .... Electronics
Russell Hawkes .... Industry
John F. Judge .... Advanced Materials
Robert L. Parker .... Copy Editor
Rex Pay .... Electronics
Hal Taylor .... NASA
James Trainor .... Military

Contributing Editors

David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach .... Art Director
Donald Strickland .... Assistant Art Director
Suzanne Montgomery .... Editorial Assistant
Sally Fosnight .... Editorial Assistant

BUREAUS

LOS ANGELES .... 9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks .... Bureau Chief
NEW YORK .... 20 East 46th Street
Michael Getler
CAPE KENNEDY .... 507 Orange Ave.
Chris Butler .... Merritt Is., Fla.
MIDWEST .... 423 N. Quentin
John L. Zimmerman .... Wichita, Kan.
PARIS .... 11 Rue Condorcet
Jean-Marie Riche
GENEVA .... 10 Rue Grenus
Frank G. McGuire

EDITORIAL ADVISORY BOARD

Dr. Peter Castruccio
Conrad H. Hoeppner
Richard F. Gompertz
Alexander Satin
Vice Adm. H. Sanders (ret.)

•

James W. Claar
Publisher

A. C. Boughton .... National Sales Manager
Paul B. Kinney .... Eastern Advertising Manager
Edwin J. Denker, Jr. .... Western Advertising Manager
Kenneth C. Blanchard. Marketing & Research Director
John N. Carlin .... Director of Circulation
Paddy Nelson .... Circulation Promotion
R. Virgil Parker .... Director of Production
Barbara Wiener .... Advertising Services Manager
Cynthia Livingstone .... Production Assistant

Published each Monday with the exception of the ast Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washngton, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President .... Wayne W. Parrish
Senior Vice President .... Louis C. James
Vice President .... Fred S. Hunter

THE COVER

STL PHOTO BY BOB CHRISTOPHER

Nuclear Detection Satellite (NDS), left, and Orbiting Geophysical Observatory (OGO) antenna test models being radiated with RF energy from source antennas to determine antenna response at TRW Space Technology Laboratories. Antenna patterns are plotted on polar and rectangular forms in central control station.

JANUARY 11 HEADLINES

Navy To Seek New Bids on Talos Missile System 10
Defense Dept. Assuming Control of Syncoms 10
Industry Anticipates RFPs Soon on SRAM 12
Polaris B-3 Program Definition Approved 13
Board Appointed To Probe Eglin Radar Fire 13
LBJ's Space Message Expected on Hill Jan. 15 14
Kiwi Destruction Planned for Test Purposes 15
Patents Sought for Recoverable Booster Concept 15
House Body Hopes To Assist Small Businesses 16
Rohr Delivers Biggest Nozzle to Thiokol 17

SPECIAL SECTION

Latest edition of M/R's Astrolog—a status report on all U.S. Satellites, Spacecraft, Space Vehicles and Missiles ... 21

SPACE SYSTEMS

New Gyros Could Be Key to MORL Stabilization 31

SPACE PROPULSION

Emulsions Under Study To Boost Energy Levels 34
Boeing Cryogenics Work Has Strong Backing 36

DEPARTMENTS

Letters 6
The Countdown 9
The Missile/Space Week® 10
Technical Countdown .. 18
The Industry Week 39
Contracts 40
Products & Processes ... 41
Names in the News 44
When & Where 45
Editorial 46

48,000 copies this issue

Hard Edge of Economy

To the Editor:

I read my husband's MISSILES & ROCKETS and your Dec. 7 editorial ("Courage and Defense Economy").

Usually, I would agree with you—but I wonder if McNamara isn't cutting a little too much this time—for our safety.

Also, if it's tax money he's busy saving I have a couple of suggestions:

1) All the junkets our re-elected and non-re-elected Congressmen are taking *right now.*

2) Staggering welfare costs.

3) Unbelievable foreign aid costs—and to some of the countries, and for some of the projects (I've just been doing some reading on this) that are really unthinkable —Communist or Communist-sympathizing.

Now if this is available for *me* to read, President Johnson must be aware.

And the way some of the defense contracts are being let to other areas, *after* they have imported workers—I would call this very bad planning from Johnson, McNamara on down. It's true I have an axe to grind: my engineer husband was let out in a huge cutback at Lockheed eight months ago, and it's been rough going ever since.

Joan Cooper
San Lorenzo, Calif.

Sweating Out Mercury

To the Editor:

M/R, Dec. 14, p. 12 ("NASA Must Decide Orion Future") contains the following quote from an unnamed "NASA official":

"(Nuclear pulse propulsion) probably is the only concept we have now that might permit *manned* missions to planets other than Mars, *including a manned landing on Mercury.*" (Italics mine.)

As if the present plans for a manned landing on the airless, waterless Moon, with 200°+F temperatures in the sunlight and 200°−F in the shadows, were not enough to jar one's sensibilities of practical considerations, how, in all hades, can anyone conceive of human survival in an inferno exceeding 600°F, the temperature of molten lead?! To be boiled or frozen solid on the Moon is one thing; but to be vaporized on Mercury is something else again!

B. F. Miessner
Miami Shores, Fla.

It is generally believed that a small area on the dark side of Mercury can accommodate human life for a brief period of time; however, the problem of getting to that area without being vaporized is one which will take a lot of planning—Ed.

Gimbaled Nozzles

To the Editor:

In your Dec. 21 issue it was stated in the report on the Thiokol 156-in. test firing that gimbaled nozzles are somewhat heavier than other TVC devices.

Studies by Arde-Portland and other agencies interested in solid-propellant rocket thrust vector control actually indicate that gimbaled nozzle TVC systems are lighter than available alternates in those cases where moderate to large amounts of vectoring are required by the vehicle application. The nozzle is somewhat heavier than the fixed nozzle typically used in other TVC systems, but control components are very much lighter, so total system weight is reduced.

In addition, the gimbaled nozzle provides other advantages. The TVC system incorporates a very small total number of components, all of which are highly reliable. The system can be completely and repeatedly checked out, including motion of the nozzle, after installation on a complete vehicle, since the control system does not depend on expelling unsanitary fluids.

The gimbaled nozzle TVC system also provides for long storage life with a minimum of maintenance. It has a very high vector angle capability well beyond current requirements.

D. W. Wagner
Program Manager
Arde-Portland
Paramus, N. J.

No condition is too extreme for

AAF ENVIRONICS*

Need a Florida environment in the Arctic? Dust-free, stabilized temperature and humidity for the Arizona desert? You pick the parameters, and an AAF Environics team will research, engineer, and produce the system needed for the job. Take the packaged environment for advanced Minuteman installations, for example. The system and controls we produced for them will operate for three years without scheduled maintenance. This Minuteman system, by the way, meets stringent requirements for ambient conditions and shock resistance . . . and features radio-interference suppression, explosion-proof operation and CBR filtration.

Can we help you with environmental control problems? Phone or write Defense Products Group, American Air Filter Co., Inc., 1270 N. Price Rd., St. Louis, Mo. 63132. Ask for Bulletin D-240.

American Air Filter

* *Our total system approach to R&D, production and engineering management of package environments involving heating, ventilating, air filtering, refrigeration, humidity control and purification.*

AAF

Circle No. 4 on Subscriber Service Card

AEROSPACE ENGINEERS

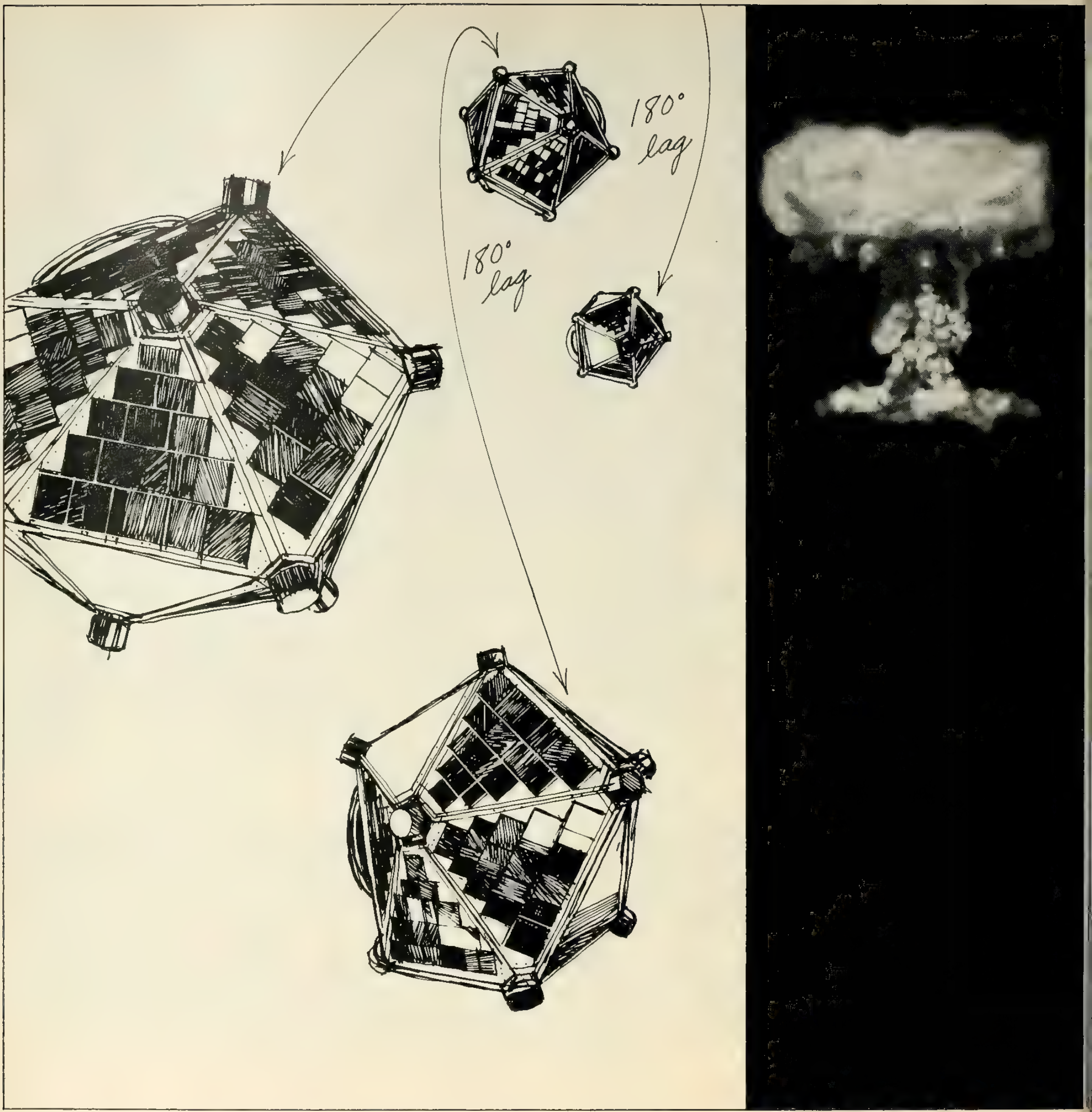
Give your career a big lift at Douglas!

Rapidly expanding activities at Douglas relating to huge new aircraft programs have created outstanding career openings. Work areas include a great new development program on what will be the biggest jet transport in the world and a variety of exciting new military and commercial projects extending through the next decade and beyond. Division between military and commercial is approximately 50-50.

We are seeking aircraft engineers with BS or advanced degrees with experience in any of the following: Stress Analysis; Load Analysis; Dynamic Analysis; Electrical Design; Structures Design; Aerodynamics; Power Plant — Thermo-Mechanical; Flight Test Instrumentation; Flight Test Data Analysis; Reliability; Advanced Systems Engineering. Openings include a number of senior positions.

For full information, please send your resume to Mr. C. A. Carrico, Professional Employment, Douglas Aircraft Company, 3851 Lakewood Boulevard, Long Beach, California. Douglas is an equal opportunity employer.

DOUGLAS
AIRCRAFT DIVISION



10-MILLION MILE GUARANTEE

Nuclear blasts within 10 million miles of earth may now be detected. Two pair of orbiting Nuclear Detection Satellites provide this protection. These spacecraft—built by TRW Space Technology Laboratories for Air Force/ARPA—are part of our national nuclear arms control program.

Today we are busy on many space projects that mean new opportunities for engineers and scientists. We are prime contractor for NASA's Orbiting Geophysical Observatory and Pioneer programs. We are developing the variable-thrust descent engines for Apollo and Surveyor lunar landings. And TRW Space Technology Laboratories continues Systems Management for the Air Force's Titan and Minuteman programs. These and other advanced space activities create opportunities in: Theoretical Physics, Systems Engineering, Radar Systems, Experimental Physics, Applied Mathematics, Space Communications, Space Physics, Antennas and Microwaves, Inertial Guidance, Analog Computers, Solid State Physics, Computer Design, Telecommunications, Digital Computers, Guidance and Navigation, Electromechanical Devices, Engineering Mechanics, Applied Aerodynamics and Propulsion Systems. For information about TRW opportunities in So. California and at Cape Kennedy, write TRW Professional Placement, One Space Park, Dept. MR-1, Redondo Beach, Calif. TRW is an equal opportunity employer.

TRW SPACE TECHNOLOGY LABORATORIES
THOMPSON RAMO WOOLDRIDGE INC.

The Countdown

WASHINGTON

GT-2 Still Scheduled for Jan. 19

The *Gemini* spacecraft for the first manned orbital flight in the series, *GT-3*, was shipped from the McDonnell plant in St. Louis to Cape Kennedy on Jan. 4. At the same time, repairs have been completed on the *Titan II* launch vehicle for the ballistic *GT-2* shot, and it is still scheduled to go on Jan. 19.

Laser Communications Experiment Planned

White Sands Missile Range will participate in the first use of laser communications with an orbiting spacecraft during this year, the Army says. It will also provide laser tracking information on orbiting space vehicles.

SSGS Still Under Evaluation

Final decision on the direction which the Standardized Space Guidance System should take is still to be made. The program is not dormant, however, and Pentagon officials expect to have it vectored within the next month or so.

First 'Wheel' Tiros Nears Flight Date

First launch of the RCA *Tiros* "cartwheel" satellite will take place later this month from Cape Kennedy. With two cameras mounted on its side, it will provide continuous coverage of the sunlit side of Earth.

No New Apollo Test Stands at MILA

NASA officials have dropped plans to build new static test stands for firing the *Apollo* Service Module and Lunar Excursion Module engines at the Merritt Island Launch Area. Instead, Launch Complex 16, used for *Titan* missiles, will be modified. Several contracts covering the work are expected to be awarded this spring. Testing of the Service Module will begin in the last half of this year, LEM tests in mid-1966.

Big Field Seeks First ERC Contract

Twenty-two companies have submitted proposals on the first contract from NASA's new Electronics Research Center. Expected to be awarded in about a month, the contract involves a study to identify the guidance and navigation research efforts that will be necessary to support future NASA interplanetary missions.

Retired Missiles Join Unemployed

Atlas and *Titan I* missiles, which will be retired from service in April and July, still have no visible future employment. Air Force officials have yet to decide whether to use them as space boosters—refurbishment costs are still too high, in the opinion of some officers. Meanwhile, a deactivation task force under Maj. Gen. L. L. Mundell is operating at Wright-Patterson AFB to ensure that the birds come down on schedule.

INDUSTRY

Cubic Wins Target Locator Subcontract

Cubic Corp., San Diego, Calif., won a $480,000 subcontract from Textron's Bell Aerosystems Co. to develop the distance-measuring subsystem for an electronic target location system for the Army. Cubic will deliver next summer two pre-production units consisting of a ground station and an airborne receiver-transmitter. The Bell visual airborne target locator system, being developed for Army Electronic Research and Development Agency, will pinpoint ground targets from aircraft, utilizing an electronically stabilized telescope.

Manned-Mission Atomic Power Supply Studied

Atomics International Div. of NAA is investigating atomic electric power supplies for manned interplanetary trips under a $90,000 contract from NASA's Manned Spacecraft Center. Drawing on SNAP technology but not a part of that program, the study involves unique radioisotope dynamic electrical power systems in which heat is converted to electricity by a turbine-generator, and covers both Brayton and Rankine Cycles. The division will recommend designs for two types of compact units for each of two categories of manned missions—Mars landing and a Mars/Venus fly-by lasting 450-600 days. Power conversion equipment is being studied by TRW Inc. under subcontract.

Honeywell Aiding Mohole Drilling

Honeywell, Inc., has been selected to build a computer control system for positioning the 300-ft. Project Mohole drilling platform within a 500-ft. circle over the drilling hole in 18,000 ft. of water. Able to withstand winds and currents of up to 30 knots, the system will use underwater sonar beacons, and surface radar markers to keep the platform centered.

Oldest Minuteman Motor Passes Test

A *Minuteman* third-stage motor has been successfully fired after storage for four years and simulated stresses of transportation to a launch site. It was the oldest motor yet fired in the continuing program to determine shelf-life of the *Minuteman* ICBM in operational silos. The motor was inspected by X-ray before and after its long storage. The static test firing was conducted by the manufacturer, Hercules Powder Co.

AEC Seeks to Aid Industry

Atomic Energy Commission's Argonne National Laboratory has set up an Office of Industrial Cooperation to encourage industrial uses of technology created at the lab. It is scheduled to become fully operational this month.

Lockheed, IAM in Preventive Discussions

Lockheed Aircraft Corp. and the International Association of Machinists will start a series of exploratory discussions late this month in a move to avert "crisis bargaining" during 1965 negotiations for a new company-union contract.

INTERNATIONAL

French Testing Submarine Missile Parts

Underwater tests of *MSBS (Mer Sol Balistique Stratégique)* missile components have begun at CERES, the Naval Missiles Test Center on the Ile du Levant near Toulon. The first *MSBS*-armed French-built nuclear submarines will be operational at the end of this decade. Five are to be built.

Firing Set From MM Site

A *Minuteman* missile will be launched from Ellsworth AFB, N.D., in the first test of an operational, SAC ICBM site. It will also be the first time that such a missile has been fired from deep within the U.S. heartland.

The possibility of firing ICBM's from operational silos has long been discussed by Defense officials. However, full distance, overland flights are considered too dangerous since the missile would fly over densely populated areas.

The launch, which is scheduled for March, will involve an unarmed missile with "only enough propellant to sustain several seconds of flight and will land within two miles of the launch point," according to the Air Force.

DOD To Operate Syncoms

DOD is taking over operation of the *Syncom II* and *Syncom III* communications satellites. The transfer from the space agency began January 1 and will be completed by March 31.

Telemetry and command stations and range and range-rate equipment operated by NASA for its *Syncom* program will be transferred to DOD along with the satellites. The DOD, however, will provide NASA with certain telemetry data of continuing scientific and engineering interest.

Syncom II was launched July 26, 1963, and *Syncom III*, Aug. 19, 1964, both from Cape Kennedy. Both are operating at altitudes of about 22,300 miles.

NASA Seeks Booster Barge

The Marshall Space Flight Center has requested bids on the conversion of a former Navy vessel into a transport for large rocket stages.

The new barge will be used to transport the *Saturn V* booster S-IC first stage from Marshall and its Michoud Operations near New Orleans to the Merritt Island Launch Area in Florida. It can also be used to haul smaller booster stages in the *Saturn* launch vehicle series.

The cargo hanger will be 190 ft. long and 41½ ft. high, with a width at the deck of 44 ft.

The vessel itself, known as a seagoing cargo barge, will be 262 ft. long and 52 ft. wide, with an operating draft of seven feet.

Included in the conversion work will be the building of the cargo hangar, reinforcement of decks, installation of an 18,000-lb. steel folding door on the cargo hangar, outfitting of a pilot house, addition of flume stabilizers to dampen the vessel's roll in heavy seas, tie-down and mooring systems, and installation of electrical power plants. The barge will have two 150-kw generators, one of which will stand in reserve.

In the cargo section there will be room for the S-IC fins and the *Saturn V* instrument unit, in addition to the S-IC.

Proposals are due January 25, with delivery to NASA in mid-1965.

Firms invited to submit proposals are the following: Avondale Shipyard Corp., New Orleans, La.; Todd Shipyards Corp., New York, N.Y.; Bethlehem Steel Co., New York, N.Y.; Aerojet General Shipyard, Jacksonville, Fla.; Rawles Brothers Shipyard, Jacksonville, Fla.; Savannah Machine and Foundry Co., Savannah, Ga.; Charleston Dry Dock and Shipbuilding Co., Charleston, S.C.; Gulfport Shipbuilding Corp., Port Arthur, Texas; and Dade Dry Dock Corp., Miami, Fla.

Talos To Be 'Contracted-Out'

The *Talos* air defense missile system will be added to the list of weapons whose production the Navy's Bureau of Weapons will "contract-out" to other than developing contractors.

BuWeps is advertising for procurement of guidance, control and air-frame components for the system on a multi-year basis.

Present guidance and control system contractor is GPI's Kearfott Div., and equipment contractors include Naval Weapons Plant, McDonnell Aircraft, and Fairchild Hiller.

Prime contractors on the *Talos* are Bendix-Mishawaka, for assembly and test, and Vitro for systems engineering.

BuWeps says that it intends to hold a conference for prospective bidders about March 1. It will mail bid solicitations, including corrected data package, about April 30.

Edwards To Get New Test Stand

A unique new $8-million rocket test stand at Edwards AFB, Calif., is under construction. When completed, the stand will have the capability of firing large solid motors in either the horizontal or vertical position and liquid engines horizontally.

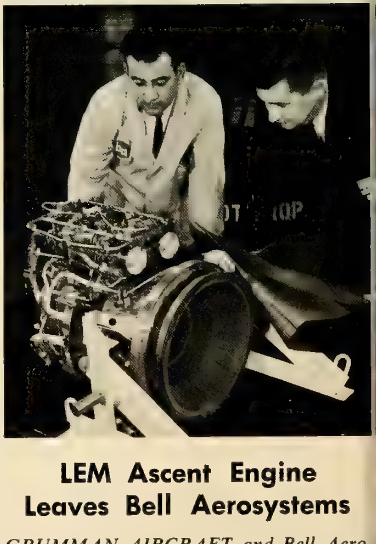
Designed by an Aerojet General Corp. subsidiary, AETRON, the stand will be used by the Air Force for R&D on high-thrust engines using exotic, high-energy propellants.

Missile Silos Tested

Scientists at the Air Force Weapons Lab at Kirtland AFB, N.M., have started simulated effects tests in a new area—the atomic over-pressures encountered in a hardened missile silo.

A scale model of a typical missile silo was recently given the full traveling shock wave by way of a primacord explosion and an earthen surcharge.

Primacord, a rope-like conventional explosive, was woven on a wooden framework and covered with the earthen surcharge. The amount of primacord was described only as several thousand feet, while the amount of surcharge remains unspecified. When the primacord was detonated, the surcharge held back the blast long enough to focus the



LEM Ascent Engine Leaves Bell Aerosystems

GRUMMAN AIRCRAFT and Bell Aerosystems engineers inspect prototype model of 3,500-lb.-thrust ablative Lunar Excursion Module ascent engine prior to its shipment from Bell to Grumman, LEM prime contractor. Engine will lift module containing two Apollo astronauts from Moon's surface and propel it to rendezvous with Command Module prior to return to Earth.

full shock wave toward the scale model silo.

Results of the test confirmed the feasibility of using the new simulation technique to gain more knowledge about protecting structures from the effects of atomic explosions.

F4-C To Get Genie Launcher

McDonnell Aircraft Co. has been asked by the Air Force Special Weapons Center at Kirtland AFB, N.M., to develop a launcher on the F4-C aircraft for the nuclear defense missile, *Genie* (AIR-2A). The launcher-missile system is to be tied into an advanced fire control system now under development for the aircraft.

Genie has been operational with Air Defense Command interceptors, such as the F-101B and the F-106, for several years. However, the use of *Genie* on the F-4C means that the Air Force will adapt the versatile fighter to the air defense mission. The Navy has long used the F-4, armed with *Sidewinder* and *Sparrow III,* in the interceptor role.

A free-flight rocket, *Genie* has a range of approximately 6 n. mi. It weighs 800 lbs. at launch and is powered by a 36,000-lb.-thrust solid motor. It is primarily designed to provide area defense against bomber attack.

The decision to use the F-4C as an interceptor is expected to considerably postpone the deployment of the YF-12A—perhaps forever. And it is a further blow to any completely new Improved Manned Interceptor to counter what the Defense Department regards as a diminishing Soviet bomber threat.

ComSat Controversy Heard

Seven organizations—including the Communications Satellite Corp. —will meet informally with the Federal Communications Commission Jan. 11 in an attempt to smooth the way for settlement of ownership and operation of initial ground stations for the global communications system (M/R, Dec. 14, p. 10).

The seven parties filed comments last week in response to a December request by the FCC for more information before making a final ruling. The controversy began last August when ComSat petitioned the FCC for exclusive ownership and control of the initial stations. Deadline for answering arguments is Jan. 18.

Those filing arguments, in addition to ComSat, include: RCA Communications, Inc.; Western Union International, U.S. Independent Telephone Association; Hawaiian Telephone Co.; American Telephone & Telegraph Co.; and Aeronautical Radio, Inc.

AT&T supported the ComSat request for sole rights of operation of the stations, but stipulated that station ownership should be on a 50-50 basis with communications companies and that the operating rights should not extend beyond the initial three or four stations. Earlier, AT&T's only reply had been that the sole ownership request would be illegal under the Communications Satellite Act of 1962.

Agena Pact Under Negotiation

NASA is negotiating with Lockheed Missiles and Space Co. for a $16-million contract to modify five *Agena D* second-stage launch vehicles for use in *Lunar Orbiter* missions.

The *Agena D* stage will be mated to an *Atlas* booster and to the *Lunar Orbiter* spacecraft for each of the five planned NASA missions.

Agena D modifications peculiar to *Lunar Orbiter* requirements will include vehicle engineering support; systems testing; overall system integration functions; shroud, adapter and interface coordination; and design fabrication of ground equipment.

The *Lunar Orbiter* program is designed to gather data on the Moon's surface, to extend scientific knowledge and to help select and confirm landing sites for the *Apollo* manned Moon landings.

Lockheed designed and developed the original *Agena* vehicle, which was first launched in 1959. *Agena* second stages have been used by NASA for such missions as *Ranger, Mariner, Nimbus* and the *Orbiting Geophysical Observatory.*

NASA's Lewis Research Center, Cleveland, is responsible for technical direction of the NASA *Atlas-Agena D* program and for procurement of the *Agena.*

Walleye PDP Awards Made

Martin Co., North American Aviation and Hughes Aircraft have received contracts from the Navy Bureau of Weapons for the program definition phase for the *Walleye* guided bomb (M/R, Dec. 21, p. 8).

Martin's award for the *Walleye* amounts to $485,000, North American's $622,000. Value of the Hughes award is not yet disclosed.

Walleye, a 1,000-lb. conventional explosive bomb with movable fins and no propulsion, is under management of the Naval Ordnance Test Station, China Lake, Calif.

ENGINEERS
SCIENTISTS

Engineers and scientists seeking a responsible position in which they may make important contributions to the aerospace industry are invited to explore opportunities in the Chemical Propellant Information Agency. The Agency, operated for the Departments of the Army, Navy and Air Force, National Aeronautics and Space Administration, and Advanced Research Projects Agency by The Johns Hopkins University Applied Physics Laboratory, is responsible for acquiring and analyzing the world literature on chemical propellant research and development.

Data acquisition requires reading, abstracting, and indexing formal progress reports generated by a large number of principal investigators in many specialized areas of chemical propulsion research; frequent personal contact with these scientists and engineers; and liaison with United States Government technical contract monitors. Respondents must be capable of synthesizing information for publication from their analysis and evaluation of these data. A bachelor's degree in mechanical or metallurgical engineering, physics, or mathematics and several years of related experience such as rocket engine design, static test, or propellant formulation are desirable.

The Applied Physics Laboratory is located in a residential suburb of Washington, D. C., an area well known for its beauty, high standards, and excellent public schools and universities.

Direct your inquiry to:
Mr. W. S. Kirby
Professional Staff Appointments

Applied Physics Laboratory
The Johns Hopkins University

8643 Georgia Avenue
Silver Spring, Maryland

An equal opportunity employer

Circle No. 5 on Subscriber Service Card

Industry To Get SRAM RFP's Soon

Program definition will follow DDR&E approval; Pentagon enthusiastic about missile; firms gear for competition

by James Trainor

REQUESTS FOR PROPOSALS to industry for a three-phase program definition should be issued for the *Short-Range Attack Missile* (*SRAM*) within the next few months, even though full-scale development is not expected to begin before early 1966.

Actual issuance of the RFP's depends on how rapidly the program package moves through Air Force and Defense Department approval channels. At the moment, the package has been submitted to Assistant Secretary of the Air Force (Research and Development) Alexander Flax. From him, it must be submitted to, and approved in the Office of the Director of Defense Research and Engineering.

• **DOD enthusiastic**—No problems are indicated in this approval process, however, since the Defense Department is highly enthusiastic about the program. An indication of DOD interest is that after the Air Force FY '66 budget request for *SRAM* had been cut, the decision was disputed and "a higher figure" was agreed upon, according to an Air Force official.

SRAM is an air-launched, short-range missile that will be carried by a wide variety of aircraft. Among those are the B-52, the F-111 (TFX) and possibly the B-58 and the F-4C. The Navy's A-7A (VAL) aircraft could also carry the weapon, although Air Force officials refuse to comment on this possibility.

An advanced manned strategic aircraft (AMSA) might be armed with such a weapon. Air Force officials feel, however, that with the present pace of the AMSA program, such a missile would be obsolete by the time the aircraft flew.

• **Program moved fast**—*SRAM* has had an extremely short gestation period in relation to some better-known Air Force programs. In March, 1964, the Strategic Air Command formulated a requirement for a defense-suppression missile. This resulted in several studies within the Air Force and the eventual evolution of the *SRAM*.

In October, 1964, a program change proposal was approved for the Air Force budget and FY '65 funds made available for further work. These funds are expected to be sufficient to carry the program through the entire PDP cycle. All the pre-program definition phase documentation requirements have been completed and once the go-ahead is given by DDR&E, the Air Force is in a position to go to industry.

• **More than Hound Dog**—*SRAM* will not replace *Hound Dog* but rather will supplement the older air-to-surface weapon. At present, each B-52 is armed with two *Hound Dog* missiles—although there had been some discussions of increasing this to four. "Considerably more" *SRAM* missiles will be carried by each bomber, however, according to Air Force officials.

The new air-launched missile will be capable of "attacking the same type of target" as *Hound Dog* and will carry either a nuclear or high-explosive warhead. It can be used for defense suppression along the penetration corridor, although it is not limited to this role, officials emphasize.

SRAM will have a much greater accuracy than *Hound Dog* and will most likely include a terminal guidance package. An inertial platform may also be included to supplement the terminal homing device or even to replace it entirely.

Capable of low-level launch, the *SRAM* may include a penetration aids package. This is something that will be determined during the program definition. Also to be determined during PDP is the type of propulsion to be used and the non-nuclear warheads that might be applicable.

• **Wide industry interest**—Ever since *SRAM* became known to industry, the Air Force has been deluged with unsolicited proposals from companies interested in the program. In fact, most of the industry has been busily forming teams in anticipation of the PDP.

While most of these combinations appear to be still in the formative stages, at least one major company has completed its arrangements. Boeing as systems integrator has teamed with Aerojet-General for propulsion, General Precision for guidance and Avco for warhead.

Aeronautical Systems Div. of the Air Force Systems Command is expected to manage the program for the Air Force. ■

Ion Engine Life Extension Seen

AN IMPORTANT step forward in development of long-life electric ion engines was achieved in this bell jar at NASA's Lewis Research Center. Until this test, filaments for producing ions in the engines lasted only a few hundred hours. New filaments tested in this program operated for up to 5,000 hours.

Has McNamara backing . . .

Polaris B-3 Program Moving Ahead

Navy gets DOD's approval to begin program definition; Lockheed likely to be selected for systems integration

THE GO-AHEAD to begin program definition of the *Polaris B-3* has been given the Navy by the Dept. of Defense. Announcement of the decision, according to industry sources, is expected soon. Navy officials place program definition as "sometime this spring."

Approximately $5 million was included in the FY '65 budget for *B-3* definition. At the time, defense officials testified before Congress that a clear need for the longer range/payload missile had not been demonstrated. However, Secretary of Defense McNamara expressed himself as "enthusiastic over the possibility of the *B-3*."

Defense Research and Engineering Chief Harold Brown, while stressing that a decision to develop a longer-range *Polaris* had not been made, pointed out to Congress that the propulsion system for such a missile would have a long lead time and development of this subsystem would follow PDP.

Although there was some discussion of open competition for the *B-3* during the hearings, there is a widespread feeling among major aerospace companies that the Navy will sole-source the *Polaris B-3* to Lockheed Missiles & Space Co. on the basis of demonstrated competence and expertise. Lockheed then would fullfill the same role as it has on the *A-1, 2* and *3* versions of *Polaris,* that of systems integration contractor.

- **Subsystem competition possible**—However, competition for various subsystems of the missile may well be thrown open to major aerospace firms. Particularly, it appears that the first and second stage propulsion units, now built by Aerojet-General Corp. and Hercules Powder Co., would be decided on a competitive basis.

Launching equipment and guidance and control systems are other likely areas of competition. The overall fire-control system may be sole-sourced to insure compatibility with the earlier three missiles.

Primary advantage of the *B-3* is a substantial increase in the range and payload over the *A-3*. Adm. I. J. Galatin said last year that "a good guess" would be that for the same 2,500-n-mi. range of the *A-3*, the Navy could double the payload of the *B-3*. Primary advantage of increased payload would be a more sophisticated penetration aids package, including such things as multiple warheads and maneuverable reentry bodies to insure target kill.

- **Improvements**—One of the advances that has made possible a *B-3* missile is a two-inch reduction in diameter of the insulating blanket around the missile. This means that the missile diameter could be increased from 54 in. to 58 in. Also, advances in materials and thrust-vector control units, coupled with higher-impulse propellants, would provide the greater range/payload.

At the same time, reduction in the size and weight of the guidance system through microminiaturization would make more weight available for payload. Accuracy would be increased dramatically so that the *Polaris B-3* would be comparable on station to the land-based *Minuteman II* ICBM's. This would allow *Polaris* to be used in a damage-limiting role as well as fulfilling the assured destruction mission that it is now assigned. ■

Board to Probe Cause of Eglin Radar Fire

A NINE-MAN BOARD, headed by Lt. Gen. Leighton I. Davis, commander of the National Range Div. of the Air Force Systems Command, has been appointed to investigate the cause of a $30-million fire in the Space Detection and Tracking Radar at Eglin AFB, Fla., Jan. 5.

The board has been given no deadline for the report.

The fire completely destroyed the new phased-array space radar, which had been undergoing operational tests and shake-down. The radar, formally called the AN/FPS-85, was built by Bendix Corp. NORAD officials said the fire had no effect on its space detection and tracking operations since the system was not yet operational. There were no injuries in the blaze.

Cause of the fire has not been determined, Air Force officials said. The radar is located at a remote site about 20 mi. from the main Eglin base complex. Fire fighters from the base as well as from the surrounding communities were called in to fight the blaze. They were handicapped by the fact that the nearest available water was eight miles from the scene. In addition, their pumping apparatus could not send water to the upper portions of the 12-story structure.

The SPADATS radar was to have been a significant addition to the NORAD space tracking system. Its electronic scanning face would give the Air Force the capability of cataloging even the smallest space objects out to distances of thousands of miles. It was also anticipated that the FPS-85 would be an integral part of the Defense Dept.'s anti-satellite weapons system by enabling extremely accurate determination of orbital parameters in a shorter time than is now required. Also the radar, as originally envisioned, would constitute only one-half of the final system. Another face, adjoining and positioned 90 degrees from the original face, was to have been built if the system proved itself.

Beyond the facts that there was a fire and that a board had been convened, the Pentagon was extremely reticent to furnish any information on the incident.

Congress Awaits LBJ Space Message

Main theme expected to be justification of space agency's budget level of about $5.25 billion; no surprises foreseen

by Hal Taylor

PRESIDENT JOHNSON will submit a special message on the U.S. space program to Congress late this week. Administration officials reported that the target date for the message to get to Capitol Hill was Jan. 15.

They said that while the message will deal primarily with the space agency budget in FY '66, matters affecting other government agencies in the space program may be discussed.

The primary purpose of the message is to permit the President to reaffirm his support for the program for the first time as an elected President.

• **No surprises**—Informed sources reported that there will be no announcement of bold, new, expensive programs, such as manned space stations or manned exploration of Mars.

It is expected, however, that the President will give the green light to the *Voyager* interplanetary spacecraft program in the budget—carrying a total price tag of more than $1 billion. This will cover four flights to Mars in the 1971 and 1973 opportunity periods.

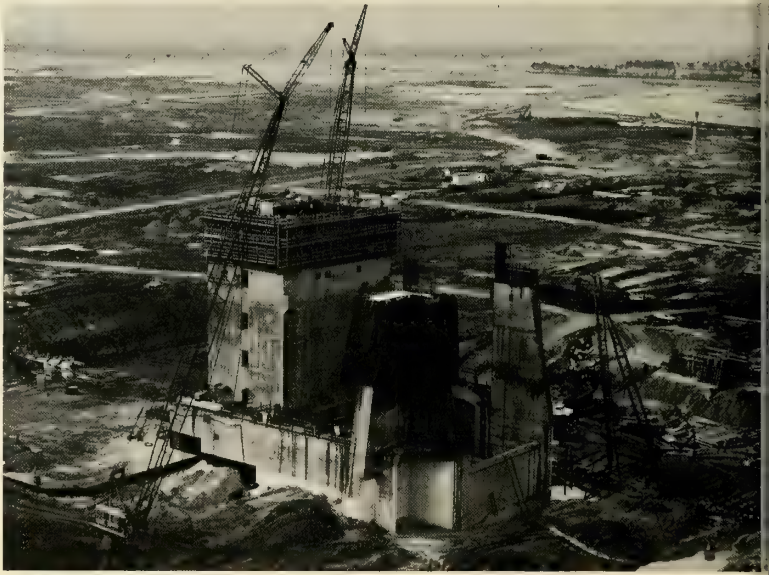
Hardware funding of the *Advanced Solar Observatory* is also expected.

The defense of the $5.25 billion budget, about the same as last year's, is expected to be the primary target of the Presidential message. This is planned in order to deal with potential Congressional critics, as well as certain groups which favored higher spending.

• **Request trimmed**—The space agency reportedly first submitted a request of $5.6 billion to the Budget Bureau, but this has been trimmed back to around $5.25 billion.

The cut-back will mean that there will be no 1969 unmanned missions to Mars, but it does not rule out some test flights of the *Voyager* spacecraft and booster. It will also delay, for at least another year, hardware development of NASA's *Apollo-X* spacecraft.

Manned space flight R&D is expected to receive about $3.1 billion in next year's budget. According to NASA officials, this will enable it to keep to the Project *Apollo* goal of landing a man on the Moon by 1970.



FUNDS FOR FACILITIES such as this test stand being built at the NASA-Mississippi Test Operations will be in FY '66 budget. This one is for static firing Saturn V's S-II stage.

The Presidential approval of the manned space flight budget will probably go a long way toward allaying the fears of some Congressmen who raised strong objections when it was reported that the Budget Bureau had put a $4.7 billion ceiling on space agency funding.

Several top-ranking Democrats on the House Space Committee said at that time that they would strongly object to making an "accordion" of the NASA program—stretching out then speeding up segments of the program. They indicated that the budget should be kept at a stable level and that they would not be averse to adding funds if necessary to maintain the pace of the program.

• **MOL considerations**—It is not known whether the President will mention the Air Force's *Manned Orbiting Laboratory* program in his space message. It is known that the Defense Dept. is devoting three more months of study to the project to answer all questions raised by certain segments of the federal government.

Despite some reports that the project would be dropped and replaced by NASA's *Apollo-X* spacecraft, it has been learned from authoritative sources that the program is going ahead based on the *Gemini*/cylindrical can concept.

In another development in the *Voyager* program, the Boeing Co. announced that it will team with two other firms in submitting a proposal for the spacecraft.

While not referring to *Voyager* by name, the firm said that proposals would cover a spacecraft designed to explore Mars in 1971, the exact timetable for the NASA program. Two firms are associated with Boeing in the proposal which will be submitted to NASA early this year.

Electro-Optical Systems, Pasadena, Calif., will provide on-board power systems. Philco Corp., Palo Alto, Calif., will handle telecommunications. ■

In safety test . . .

Kiwi To Be Deliberately Destroyed

'Kiwi-TNT' test aimed at learning effects of going critical during firing; many experiments planned to measure responses

THE JOINT AEC-NASA Nuclear Rocket Development Station (NRDS) has scheduled a reactor safety experiment with a modified Kiwi-B 4E rocket reactor to determine what happens when a reactor goes "critical" during operation.

The test, slated for late last week or early this week at Jackass Flats, Nev., will mark the first time during the safety test series that a reactor has been deliberately destroyed.

The power excursion, part of the *Rover* flight safety program of the AEC and NASA, will be conducted by the Los Alamos Scientific Laboratory (LASL), which is operated for the AEC by the University of California.

The test will be called "Kiwi-TNT"—the latter an abbreviation for Transient Nuclear Test. The terms "power excursion" and "transient" refer to the response of the reactor induced by large and rapid insertions of reactivity, causing a sudden increase in the reactor power.

Dr. L. D. P. King, head of LASL *Rover* Flight Safety Office, said that the controlled Kiwi excursion will be used to obtain basic reactor shutdown information which can be used to predict theoretically the dynamic behavior of nuclear rocket reactors under a wide range of accident conditions.

During the test, scientists will be able to observe dynamic behavior of the uranium graphite reactor system to ultrahigh temperatures. Detailed post-test diagnosis of the event will be facilitated by extensive instrumentation and photographic coverage. One major test objective is to determine the release and subsequent movement of effluent from the reactor.

• **Instant destruction**—It is planned that the reactor will be deliberately self-destroyed in a matter of milliseconds by a large and very rapid departure from sub-criticality to super-criticality, achieved by rapid rotation of the control drums. This is expected to generate tens of millions of Btu's of thermal energy within the reactor. Most of this will be absorbed in raising the graphite core to its vaporization point; less than 1% will be converted to kinetic energy.

Expected total energy release from Kiwi-TNT (about 10^{21} fissions or 30,000 megawatt-seconds) is at least 100 times greater than any known previous reactor transient experiment. Even so, off-site radiation is expected to be well within levels necessary to meet recommendations of the Federal Radiation Council for normal peacetime operations.

The Kiwi-TNT reactor, mounted on its test car, is located at the test point about 600 ft. from Test Cell C at NRDS, a government-controlled area. Extensive arrays of fallout trays and air samplers have been located around the test point to study local radiation levels during and after the test.

• **Experiments**—Eight separate auxiliary experiments involving some 150 capsules will be placed adjacent to the reactor by LASL to study the response of various types of materials to the unique nuclear environment created by Kiwi-TNT. In addition, six other encapsulated scientific experiments will be conducted in the Kiwi-TNT environment.

These tests will involve:

(1) *Rover* destruct system material;
(2) SNAP and reactor fuel;
(3) Civilian power reactor fuels;
(4) Releases of fission products from *Rover* fuel to sea water;
(5) Power burst reactor fuel; and
(6) New air filter materials.

LASL had planned originally to force water into the core to cause the excursion; however, the experiment was modified to permit a more accurate measurement of the amount and rate of reactivity addition, the dynamic response of the reactor, and the effluent release and movement—all of which are major test objectives.

Rover, sponsored jointly by the AEC and NASA through their Space Nuclear Propulsion Office, is the nation's program to develop nuclear rocket technology for space exploration. ■

MSFC Seeks Patents for ROMBUS Concept

MARSHALL SPACE Flight Center has applied for its first patents on a recoverable spacecraft booster concept. It is *ROMBUS* (*Reusable Orbital Module—Booster and Utility Shuttle*), which would place about 1 million lbs. of payload in a circular 175-mi. orbit.

The concept was designed by Philip Bono, chief advanced project engineer of future space systems at Douglas Missile & Space Systems Div., under a NASA-funded study. There are no present plans for developing *ROMBUS*, but Marshall officials believe it may be useful in future planning.

The concept is of a highly maneuverable vehicle, combining reusability with high reliability. Compared with today's expendable boosters, it would materially reduce cost of orbiting payloads. Bono estimates *ROMBUS* could be used 20 times or more in a 10-year operational life, and could be developed by the late 1970's.

The conical *ROMBUS* is compact by standards of most vehicles being studied in long-range planning. Overall height is only 95 ft. and base is 80-ft.-dia. It would orbit with a self-contained propulsion system, that also could be used for rejection and landing retrothrust. Eight detachable liquid hydrogen tanks are strapped on the vehicle for initial boost. They could be reused after ocean recovery.

Key to *ROMBUS* versatility is a multi-purpose plug-nozzle engine, which could survive re-entry heating. Landing and recovery through use of both parachutes and retrothrust of main engine with a final maneuver in which four landing legs are extended are other attributes.

While opportunities increase . . .

Small Business Pacts Continue Decline

House group says downward trend in government awards to smaller firms must be reversed; reason for condition not clear

by Heather M. David

THE PERCENTAGE OF procurement awards to small businesses has been plunging steadily downward, while at the same time small businesses have increasingly failed to respond to bid invitations for which they are eligible.

The House procurement subcommittee of the Select Committee on Small Business said that while DOD procurements, for instance, increased by $1.1 billion in FY 1963, small business awards declined by $268 million. Prime procurement by the National Aeronautics and Space Administration doubled during this period, the committee said, while its procurement from small business dropped from 11.7% to 8.5%.

This decline, the committee said in a report to the House, must be reversed. Rep. Abraham Multer (D-N.Y.), chairman of the subcommittee, cautioned that "in the face of cutbacks in defense spending, we must be sure that small business will not bear an unfair share of the retrenchment burden."

- **Failure to bid**—Mystery lies in the fact that small businesses are failing to bid when invited, the committee indicated. In FY 1963, for instance, procurements offered to small business for bids increased $900 million over the previous year. However, procurements on which small business did not bid increased from $664 million in FY 1962 to $1.2 billion in FY 1963. There are no known reasons or revealing patterns in these failures to bid, the committee stated.

There appears to be some reversal in this trend in DOD's 1964 figures, however. While the high-dollar missile and space system program awards by DOD declined by $1 billion, small business awards remained at approximately the previous year's percentage.

NASA has not released its figures for FY 1964. The Atomic Energy Commission had a decline in small business procurements, from $83 million in 1963 to $61 million in 1964.

"DOD must continue to aggressively enforce its small business prime procurement program during 1965 to maintain or better its 1964 results in the face of expected further curtailment in defense spending in 1965," the committee said. A shift in defense spending, to space research projects from development and major hard goods, may increase small business participation, the report indicated, since it usually fares better in competing for research contracts than for development.

NASA was urged to reexamine its procurement programs and techniques to determine how best to maximize competition and utilize small business capability. Its opportunity lies in matching small business capabilities with research requirements.

- **Weighted guidelines**—The committee recommended that DOD look into its policies of weighted guidelines since it tends to discourage subcontracting opportunity. As presently administered, a higher profit allowance for in-house work is provided than for subcontracting, the committee said. This policy should be reexamined with a view toward reversing the discouraging tendency by appropriate adjustment of profit allowances, the group recommended. The situation could be worsened by a cutback in 1965 defense spending, which could tempt contractors to change from small business subcontracting to in-house performance.

- **Patent changes**—The committee also called for changes in the patent statute that some small businesses contend allows prime contractors to infringe upon their patents. DOD takes the position that government procurement is not to be held up by insubstantial claims, unreasonable royalty demands and refusal to license second sources. The committee stressed that changes should be made that would encourage and reward inventive effort and small business initiative, without impeding procurement effort in time of war or national emergency.

Formal recommendations to study a raft of these problems were made by the committee, including the reasons why small businesses are failing to respond to bid invitations.

NASA was urged to more effectively break out components for competitive procurement, increase set-aside procurements, more aggressively monitor the small business subcontracting program, and maximize competition by utilizing small business technological skills. ■

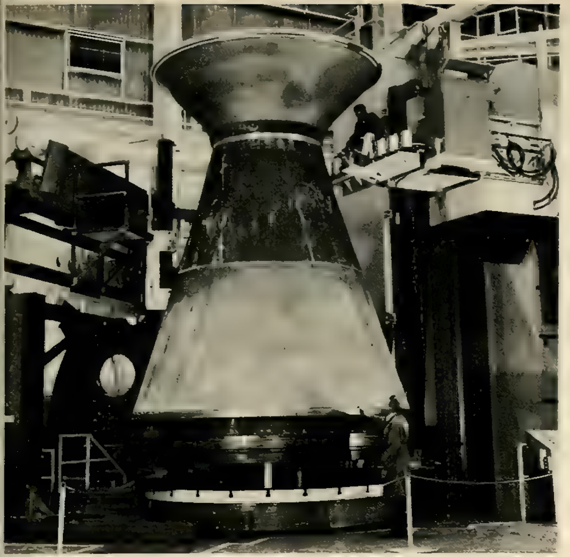
Cost Cut Sought for R&D

ABOLISHMENT OF the 20% flat reimbursement rate for indirect costs connected with research contracts has been recommended by the House Science, Research and Development subcommittee of the Space Committee.

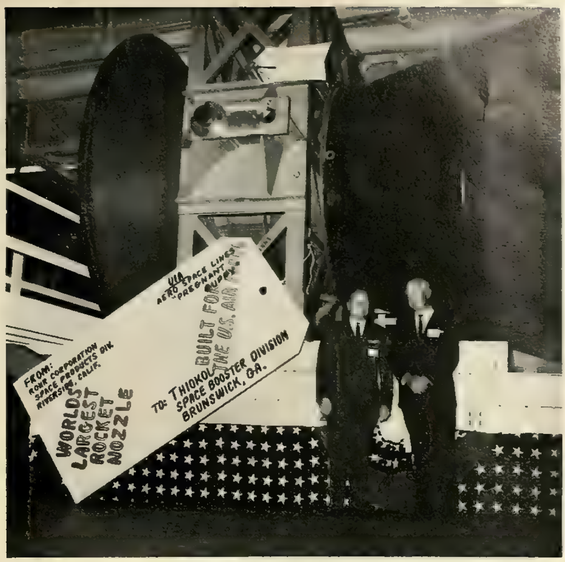
However, the group said a reasonable trial period of operation should be given to a new set of regulations that are forthcoming from the Bureau of the Budget, in Circular A-21. This document, which will be issued to all Federal agencies, is being revised to make the procedure less complicated and more realistic "by working out some of the problems turned up the past few years of trial," it was testified. However, exact revisions have not been spelled out.

If it is then determined that such a uniform reimbursement policy is unworkable, the committee said, the Congress should enact legislation. This would set appropriate indirect cost principles into effect for all government agencies.

The group, which is chaired by Rep. Emilio Q. Daddario (D-Conn.), also asked that the Bureau of the Budget set up criteria for cost sharing by universities and government agencies based on their mutual interests. The committee indicated that precautions should be taken so that the parties both understand and agree on cost-sharing in advance of the grant.



FILAMENT WINDING at Rohr Space Products Div. on ablative rocket engine nozzle built for Thiokol's 156-in. solid booster, due for static firing in Georgia next month.


VIA AERO SPACE LINES "PREGNANT GUPPY"
FROM: ROHR CORPORATION SPACE PRODUCTS DIV. RIVERSIDE, CALIF.
WORLDS LARGEST ROCKET NOZZLE
BUILT FOR THE U.S. AIR
TO: THIOKOL SPACE BOOSTER DIVISION BRUNSWICK, GA.

PRESENT AT DELIVERY ceremonies in Riverside on Jan. 4 were Brig. Gen. Joseph S. Bleymaier, SSD deputy commander for manned systems, and Rohr board chairman Fred H. Rohr.

19.5 feet high . . .

World's Biggest Nozzle Delivered

Rohr-built assembly to be used in 156-in. solid tests starting at Thiokol-Brunswick next month; bigger nozzles planned

RIVERSIDE, CALIF.—The world's largest rocket nozzle has been delivered by Rohr Corporation to Thiokol Chemical Corp., and is due to arrive at Thiokol's Brunswick, Ga., facility Jan. 11 for static-testing of that firm's 156-in. big solid next month.

The big nozzle is 19.5 ft. high, has an exit cone diameter of 168 in., and weighs 20,000 lbs. Total shipping weight, complete with buck and pallet, is 34,000 lbs.—heaviest and largest load that can be carried by the converted Boeing Stratocruiser, the "Pregnant Guppy," operated by Aero Spacelines, Inc., of Van Nuys, Calif., which was to fly it to Brunswick.

First firing at Brunswick is expected in mid-February, as part of the Dept. of Defense/NASA solid-propellant rocket motor program for the Air Force Space Systems Division. Following the 156-in. firing, the nozzle shell, which comprises about one-third of nozzle length and is made of 18% nickel maraging steel, will be returned to Rohr-Riverside for relining and attachment to a new nozzle of the same size, for use this fall in a 260-in. solid firing. The shell attaches to an adapter required to fit the same-size nozzle to a 260-in. case.

Rohr is currently fabricating another nozzle with the same general dimensions (although materials and design may differ slightly) for a 260-in. firing scheduled prior to July. Both nozzles for the 260-in. firings are of the 156-in. rocket size, but are being adapted with a maraging steel adapter section, which Rohr is also fabricating.

- **Thinking bigger**—The company says it is preparing to construct larger nozzles, even though no definite programs are yet established, and is acquiring a larger boring machine at its Chula Vista, Calif., plant to handle a 50-ft. diameter. The present machine can provide a 20-ft. diameter. Rohr says it will also install a new tape-wrapping and filament-winding machine that will accept a piece 26 ft. high.

Segments for the shell of the current nozzle were built up at the Chula Vista plant using thick weldments of the 18% nickel maraging steel, heaviest gage yet formed and welded in the industry.

At Riverside, the entrance cone, throat sections and exit cone were lined with ablatives—including carbon, graphite and silica fabrics impregnated with phenolic resins, and cured in Rohr's recently installed 176-in. hydroclave. Exit cone section itself required more than 21 miles of ablative tape, and weighs approximately four tons.

Officials on hand for delivery ceremonies at Riverside Jan. 4 included Brig. Gen. Joseph S. Bleymaier, deputy commander for manned systems in the Space Systems Div.; Col. Harold W. Robbins, director of SSD's large solid rocket motor program; and Fred H. Rohr, chairman of the board and chief executive officer of Rohr Corp. ■

Technical Countdown

ELECTRONICS

Radar Exhibits Highest Known Resolution

A microwave radar, developed by Cornell Aeronautical Laboratory for cross-section measurements, has a demonstrated range resolution of 3 in.—possibly the most accurate ever achieved. Used against scale-model targets at Cornell's Buffalo facility, the radar has revealed surface cracks in metal-clad wooden models, CAL scientists disclosed. Called the Delta Radar, it is a quasi-monostatic system employing two antennas and ultra-linear frequency modulation. The frequency sweep is from 8.2-11.7 gc at 123 times per sec. The research instrument was developed by CAL for Bell Telephone Laboratories for use in support of the Army's *Nike-X* program.

Sanders Wins Saturn V Display Contract

The Operational Display System to be used in the automatic pre-launch checkout of NASA's big *Saturn V* launch vehicle will be developed by Sanders Associates, Inc., for Marshall Space Flight Center. The $7.4-million contract includes manufacture and installation of seven systems—each comprised of four major subsystems. The latter include a data processor, monitor and control display consoles, interface logic and refresh memories, and data conversion equipment (providing hard-copy, slide-reference, and closed-circuit TV capabilities). A total of 54 display consoles will be required. Three systems are scheduled for Marshall (the first by April) and four will go to Launch Complex 39 at Cape Kennedy.

Photomapper Cuts Measurement Time

Compilation time of topographic stereo models can now be reduced from 25 hours (a previous average) to about 45 minutes through use of a newly developed photomapper, built by Bunker-Ramo for the U.S. Army Corps of Engineers, Fort Belvoir, Va., under a $992,000 contract. Altitude data so necessary for producing topographic maps is extracted automatically from stereo pairs of aerial photographs. Vertical accuracy, developers claim, is comparable to that obtained with precise, manually-operated stereo map-compilation instruments now in use. Altitude is determined by the new system using hybrid analog and digital techniques to locate corresponding imagery on stereo pairs. Output is an "orthophoto" showing 10-meter contour lines as boundaries between successive grey-level changes.

Simulated Nuclear Effects Examined

Scientists at the Air Force Weapons Laboratory at Kirtland AFB in Albuquerque, N.M., have developed a unit called "Ultrafast Pulsed Power System," reportedly capable of generating 20,000 megawatts of power in 50-nanosecond pulses. Developed under a $750,000 contract by Field Emission Corp., of McMinnville, Ore., the device employs 15 large capacitors (for energy storage and pulse forming), connected in parallel and charged from conventional power outlets. Once energized, the load is dumped into a common circuit by a beam of ultraviolet light. The sophisticated switching system funnels the charge from the 15 units to the common target within four nanoseconds. The 320,000-volt system unloads on an exploding bridgewire whose violent reaction produces the required simulated nuclear effect. Weapons Lab scientists will use the device to simulate and study light output, plasma production, shock waves and other effects associated with a nuclear explosion.

GE Fuel Cell Studied For MOL

General Electric Co. scientists have completed a study of the applicability of the fuel cell developed for the *Gemini* spacecraft to the Air Force's *Manned Orbital Laboratory* (*MOL*). The study, conducted at the firm's Direct Energy Conversion Operation in Lynn, Mass., was part of the broad *MOL* electrical power system study being conducted jointly with GE's Missile and Space Div. for the Air Force. GE has pressed hard, and with some success, for an expanded space role for the ion-exchange-membrane cell the firm developed for *Gemini* (M/R, June 8, p. 29). The cell will be used aboard the *Biosatellite,* for which GE is also prime.

Dish Deflection Monitor Developed

An automatic theodolite system that monitors the shape of dish antennas to an accuracy of ±5 sec. of arc is being developed for NASA Goddard Space Flight Center by ITT Federal Laboratories. The Antenna Contour Measuring Equipment (ACME) will measure contour and structural deflections of 40-ft. and 85-ft. tracking antennas. Measurements are made on a point-to-point basis and can be independent of antenna motion or position. The theodolite, mounted at the antenna vertex, consists of a photoelectric sensor carried in a two-axis mount with precision angle encoders. It points in sequence at several hundred targets at known distances on the antenna surface. Target azimuth and elevation angles relative to the vertex are measured and the angular coordinates are punched into paper tape. The present contract calls for delivery of one ACME unit to Goddard by August 1965. After checkout, it will be returned to Federal Labs for installation at the Rosman Tracking Station, N.C.

OPTICS

Large Mirror Ordered By Kitt Peak

A 151-in.-dia. fuzed-quartz mirror blank will be produced by General Electric's Cleveland lamp-glass plant for use at the Kitt Peak Observatory near Tucson, Ariz. The $1-million contract was awarded GE last week by the Association of Universities for Research in Astronomy. The latter, operator of the Observatory, is sponsored by the National Science Foundation.

Twinkle, Twinkle Little Satellite

Satellites can be made to wink at an observer simply by using a rudimentary optical filter on the ground. The new technique, developed by Kenneth R. Garren of NASA's Langley Research Center, will render even some faint targets in space optically visible when they are in the sunlit regions. In essence, an observer looks at his target through a rotating filter wheel, half of which obscures the target when the star background is transmitted, while the other half obscures the star background when the target image is transmitted. By this means, a blinking sensation is achieved, allowing targets of the order of fourth and fifth magnitude to be detected and identified—a feat that ordinarily calls for large amounts of on-board beacon power.

ASTROLOG

Current status of U.S. missile and space programs

Satellites and Spacecraft

ADVANCED ORBITING SOLAR OBSERVATORY (NASA)

Republic, prime. DESCRIPTION: 1,250-lb. spacecraft to make detailed measurements of Sun's solar radiation; greater pointing accuracy (5 arc sec) than OSO; launch vehicle, THRUST AUGMENTED THOR-AGENA. STATUS: Component development; planned to dovetail with OSO, with the first spacecraft launched in 1969-70.

APPLICATIONS TECHNOLOGY SATELLITE (NASA)

Hughes, prime. DESCRIPTION: Five-satellite program to test communication and meteorological equipment at medium and synchronous orbit; test bed for gravity gradient communications and meteorological experiments; weight, 700 lbs.; launch vehicle, ATLAS-AGENA. STATUS: Development; first flight scheduled for late 1966.

APOLLO (NASA)

North American, Command & Service modules, systems integration; Grumman, Lunar Excursion Module (LEM); MIT, guidance development; Collins Radio, telecommunications; Honeywell, stabilization & control; AiResearch, environmental control; Northrop-Ventura, parachute recovery; Lockheed Propulsion Co., escape tower rocket; Marquardt, reaction controls; IBM, realtime computer complex; Westinghouse, power conversion equipment. Lunar Excursion Module, prime, Grumman; descent engine, Rocketdyne & TRW Space Technology Laboratories; ascent engine, Bell Aerosystems; environmental control, Hamilton Standard; reaction control thruster, Marquardt; guidance, MIT; radar & communications instruments, RCA; TMC, telemetry, Radiation Inc.; fuel cell, Pratt & Whitney; external visual display, Farand Optical. DESCRIPTION: Three-man spacecraft for Earth-orbital, lunar-orbital and lunar-landing missions. Boosters: SATURN I and SATURN IB for Earth orbits; SATURN V for lunar rendezvous and landing missions; 3-modular spacecraft: Command Module weight, five tons; Service Module, 23 tons; Lunar Excursion Module, 12.75 tons; total weight, 85,000 lbs. STATUS: First of a series of unmanned orbital tests began with a boilerplate model launch on SA-7, Sept. 18; Little Joe II unmanned abort test successful, Dec. 8; lunar orbits scheduled 1968; lunar landing by 1970; first manned orbital flight due last half of 1966.

ASSET (Air Force)

McDonnell Aircraft Corp., prime; Honeywell, gyros; Bell Labs, guidance. DESCRIPTION: Aerothermodynamic/elastic Structural Systems Environmental Tests for various materials combinations during re-entry; delta-shaped re-entry vehicle; two versions planned weighing 1,100 lbs. (4 vehicles) and 1,200 lbs. (2); length, 68.7 in.; span, 58.9 in. STATUS: Development. One AMR shot in September, 1963, successful although vehicle not recovered; third vehicle successfully launched and recovered, July 22; fourth launched Oct. 28; fifth successfully launched Dec. 8; one shot remains in program (see START).

BIOS (NASA)

GE, prime. DESCRIPTION: 1,000-lb. satellites to test effects of space environment on plants, animals (primates) and other biological specimens; launch vehicle, THRUST-AUGMENTED DELTA. STATUS: Six flight models to be built; first flight in December, 1965; others to follow at three-month intervals; first experiments selected in February.

COMSAT CORP. SATELLITE PROGRAM

Studies being performed by Hughes, TRW with ITT, and AT&T and RCA as joint contractors. STUDIES: AT&T/RCA, 18 satellites, medium-altitude random orbit; STL/ITT, 12 satellites, medium altitude, controlled orbit using gravity gradient stabilization; Hughes 2nd-generation synchronous orbit system. STATUS: First satellites to be in orbit by mid-1966, with entire system operational by mid-1967.

DISCOVERER (Air Force Program 622A)

Lockheed, prime; GE, re-entry vehicle. DESCRIPTION: THOR-AGENA and ATLAS-AGENA launchings of stabilized satellites; main purpose is to test techniques and components for military space systems. STATUS: All data on program classified as part of DOD information policy; however, indications are that program has been cut back or ended as more economical vehicles have come into use.

EARLY BIRD (ComSat Corp.)

Hughes, prime. DESCRIPTION: Experimental modified syncom to be placed in 22,300-mi. stationary orbit and provide 240 two-way telephone channels between U.S. and Europe or simultaneous transmission of 22 or more telegraph messages; booster, THRUST-AUGMENTED DELTA. STATUS: Development; contract calls for delivery of first satellite by April, 1965; launch scheduled for mid-1965.

ECHO (NASA)

Langley Research Center, prime. DESCRIPTION: ECHO I, 135-ft. inflatable sphere in 700- to 805-mi. orbit; passive communication satellite; booster, THOR for ballistic tests; THOR-AGENA for orbital. STATUS: Program complete; ECHO I in orbit since Aug. 12, 1960; two ballistic shots in 1962 unsuccessful; ECHO II launched from Vandenberg Jan. 27; U.S.-USSR conducting series of cooperative experiments using ECHO.

GEMINI (NASA)

McDonnell, prime; Rocketdyne, spacecraft propulsion; General Electric, fuel cell; IBM, guidance system integration and computer; Honeywell, guidance; Westinghouse, rendezvous radar; AiResearch, environment. DESCRIPTION: Bigger and heavier MERCURY-type capsule to carry two men for up to two weeks; TITAN II to be used as booster; ATLAS-launched AGENA will be used for rendezvous missions; 15 spacecraft will be produced. STATUS: Development; 12 flights planned; will be used to determine feasibility of rendezvous for lunar mission and long-duration manned flight; first unmanned flight, April, 1964, successful; second scheduled for January; four manned flights, including one rendezvous mission, planned for 1965; manned and rendezvous flights, 1965-67; AF participating in program, and will modify GEMINI capsules for MANNED ORBITING LABORATORY.

GEOS (NASA)

Applied Physics Laboratory, prime. DESCRIPTION: 350-lb. geodetic satellite (similar to ANNA) to carry flashing-light beacons, electronic beacons and optical and radar reflectors; launch vehicle, THRUST-AUGMENTED DELTA; 700-900-mi. orbit at a 59-degree inclination. STATUS: First flight planned in third quarter 1965. PAGEOS passive satellite developed by Langley Research Center will also be launched in the first half of 66.

HYPERSONIC RESEARCH VEHICLE (AF, NASA)

No contractors announced. DESCRIPTION: Manned, hypersonic spacecraft capable of Earth-to-orbit-and-return; turbofan, Mach 0-3; ramjet, Mach 3-8 or 10 (oxygen collected and liquefied during this cycle); Mach 8-10 orbital speeds, LH_2-LOX rocket. STATUS: Joint NASA-AF research program approved; NASA funding $2.5 million in FY '65; AF has advanced technology program in six pertinent areas (mostly engine developments) in FY '65. NASA has requested proposals for conceptual and preliminary design of a research engine; engine flight test planned for early 1968.

ICBM ALARM (Formerly MIDAS) (Air Force Program 239A)

Lockheed, prime; Aerojet, IR detector system. DESCRIPTION: Early-warning random orbit satellite; detect ICBM launchings by IR; two flights conducted in 1963 detected solid and liquid missile launches; satellites are launched piggy-back on various AF boosters. STATUS: Development; no decision on deployment; reportedly competing with over-the-horizon radar.

INTERPLANETARY MONITORING PLATFORM (NASA)

Goddard Space Flight Center, prime; Martin Co. developing nuclear power unit. DESCRIPTION: 140-lb. satellite launched into cislunar-space orbit with an apogee of more than 100,000 mi.; will measure radiation and solar flare hazards in advance of Project APOLLO; launched by DELTA booster from AMR. STATUS: IMP-I launched in December, 1963; IMP-II launched Oct. 3; three more satellites are planned, two to be placed in lunar orbit; later flights will use a nuclear power unit as replacement for solar cells; Designation, IMP-A is EXPLORER XVIII.

ISIS (Canada, U.S.)

Canadian Defense Research Board, satellite; NASA, launch vehicle. DESCRIPTION: Three-satellite follow-on program to ALOUETTE to continue ionospheric studies. STATUS: Design of ISIS A began in 1964 with launch planned in 1967; B and C to be launched in 1968, 1969.

LUNAR LOGISTICS SYSTEM (NASA)

Studies have been conducted by Grumman, TRW/STL and Northrop. DESCRIPTION: Spacecraft to carry support payloads to the Moon. Two designs under study—LEM truck with 7,000-lb. payload and logistics spacecraft with 25,000 to 30,000 lb. payload; booster: SATURN V. STATUS: Program definition of the LEM truck planned in FY '66; program would cost about $1 billion.

LUNAR ORBITER PHOTO CRAFT (NASA)

Boeing, prime; RCA, power and communications; Eastman Kodak, cameras; Marquardt, maneuvering engine. DESCRIPTION: 830-lb. spacecraft launched by ATLAS-AGENA will orbit Moon taking pictures of lunar surface; radioactive and geodetic measurements will also be taken. STATUS: Five flights scheduled beginning in mid-1966.

MANNED ORBITING LABORATORY (Air Force)

Aerospace Corp., systems engineering & technical direction; study contracts awarded to Douglas, GE, and Martin on the ORBITING SPACE STATION (OSS); also contracts for studies of selected subsystems. DESCRIPTION: Two-man spacecraft to establish military usefulness of man in space; booster, TITAN III-C; GEMINI-B capsule atop 10-ft.-dia., 14-ft.-long canister lab; total weight about 18,000 lbs.; orbit below 350 mi.; flights of 30 days in shirt-sleeve environment planned. STATUS: Pre-program definition; RFPs for program definition expected to be issued in early 1965; unmanned GEMINI launch early 1966; unmanned canister launch late 1967, manned first half 1968; rendezvous capability possible later.

MARINER (NASA)

Jet Propulsion Laboratory, prime. DESCRIPTION: 570-lb. unmanned spacecraft for early interplanetary missions to vicinity of Mars and Venus; boosted by ATLAS-AGENA. STATUS: First scheduled Venus fly-by, August, 1962, unsuccessful after booster failure; second passed within 21,594 mi. of Venus, Dec. 14; two Mars fly-by spacecraft launched in November, 1964; first on Nov. 5 failed due to shroud malfunction; second on Nov. 28 successful, expected to pass Mars July 14; because of press of maintaining APOLLO schedules, NASA has dropped plans for 1966 & 1969 Mars shots; agency will go directly to VOYAGER, a 7,000-9,000 lb. spacecraft for missions in 1970s.

MILITARY COMMUNICATIONS SATELLITE (Program 369) (AF,DCA, Army)

Aerospace Corp., systems engineering & technical direction; Philco, prime. DESCRIPTION: Multiple-launch, random, active repeater comsat; 16-24 satellites launched in groups of 6-8 satellites in 19,000 n.mi. polar orbits; weight about 100 lbs.; TITAN-III-C booster. STATUS: Full-scale development as an "interim" system which is to be in operation in 1966. DCA has requested ideas from industry on an Advanced Communication Satellite system; study contracts expected to be awarded by April 15.

NATIONAL ORBITING SPACE STATION (NASA, AF)

Many studies awarded. DESCRIPTION: Manned space station with orbital lifetime of one to five years for testing components and techniques in the space environment; weight ranges under study vary from 15,000-20,000 up to 200,000 lbs. STATUS: Decision not expected for one to four years; APOLLO-X, AF MANNED ORBITING LABORATORY, MANNED ORBITING RESEARCH LABORATORY and LARGE ORBITING RESEARCH LABORATORY being considered; program definition of APOLLO-X expected in FY '66; longer-life stations delayed until 1970's.

NIMBUS (NASA)

Goddard Space Flight Center, prime; GE, integration and testing; RCA, videcon cameras. DESCRIPTION: 830-lb. second-generation weather satellite; Earth-stabilized polar orbiting; TV cameras and IR scanners in payload; THOR-AGENA B booster. STATUS: First launching successful August 28; picture & IR quality good in spite of satellite's elliptical orbit; satellite quit transmitting Sept. 23; second scheduled for launch within a year; two R&D satellites to be funded in FY '65; uses Automatic Picture Transmission system.

NUCLEAR DETECTION SATELLITES (Formerly Vela) (ARPA)

TRW Space Technology Laboratories, prime; Los Alamos Scientific Lab/Aerospace Corp., payload. DESCRIPTION: 20-sided, 485-lb. satellite for detection of nuclear explosions in space; 50,000-mi. orbit; booster, ATLAS-AGENA; launched in pairs. STATUS: First pair successfully launched in October, 1963; second pair successfully launched July 17, 1964; three pairs remain.

OAO (NASA)

Grumman, prime; Westinghouse, ground station, components; GE, stabilization and control; Kollsman, star trackers; IBM, data processor and storage; Hughes and Avco, communications equipment. DESCRIPTION: 3,600-lb. orbiting astronomical satellite to study ultraviolet spectrum from approximately 1,200 Å to 4,000 Å; four major experiments selected; one piggyback; booster, ATLAS-AGENA D. STATUS: Three flights beginning in late 1965.

OGO (NASA)

TRW Space Technology Laboratores, prime; DESCRIPTION: 1,000-lb. satellite with instruments for geophysical measurements; polar (POGO) and eccentric (EGO) shots planned; can carry more than 20 experiments; ATLAS-AGENA B, THRUST-AUGMENTED THOR boosters. STATUS: First launch on Sept. 4 partially successful; 16 of 20 experiments working; next launch (a POGO) early 1965.

OSO (NASA)

Ball Brothers, prime. DESCRIPTION: OSO 1,458-lb. orbiting solar observatory; OSO II, 535-lbs.; DELTA booster; S-16 early version; S-17 and S-57 advanced versions. STATUS: First flight Mar. 7, 1962, highly successful; first flight for S-17 planned for second quarter 1964 delayed until 1965; five more flights planned.

PEGASUS (NASA)

Fairchild Hiller, prime. DESCRIPTION: 3,400-lb. meteoroid-detection satellite employing two 50 x 15 ft. extendable detector wings; Earth orbit 300 to 800 mi.; booster, SATURN I. STATUS: Development; will measure size, energy and frequency of meteoroids to evaluate hazards of impact with manned spacecraft; first launch scheduled in February-March 1965; formerly known as METEOROID DETECTION SATELLITE; two more satellites will be launched as part of SATURN I development program. Cislunar Pegasus may be launched late in this decade.

PIONEER (NASA)

TRW Space Technology Laboratories. DESCRIPTION: 140-lb. spin-stabilized solar probe; augmented DELTA launch vehicle; cylindrical; covered with 10,000 solar cells; four outrigger booms for stabilization; five experiments, 60 to 90-million-mi. communication capability. STATUS: Seven launches in program; early 1965 launch schedule set; orbits range from 0.8 to 1.2 au for 6-mo. lifetime; EXTENDED PIONEER development to begin in FY '66. ADVANCED PIONEER under study.

PROJECT SCANNER (NASA)

Honeywell, fabrication and integration; Baird-Atomic; star-mapper telescope; Santa Barbara Research Center, dual radiometers. DESCRIPTION: Unmanned scientific satellite to measure natural radiation gradients of Earth's horizon to determine utility of spacecraft horizon sensors. STATUS: Flights to begin in 1965.

RADIO ASTRONOMY OBSERVATORY (NASA)

Goddard, prime for first two spacecraft with industry to build remaining four. DESCRIPTION: 270-lb. satellite which will have four 750-ft. extendable antennas to pinpoint radio emissions in space. STATUS: Program approval and funding expected in FY '66 budget, with first launch by a THRUST AUGMENTED DELTA in 1967.

RANGER (NASA)

JPL, prime; Hercules, retro-rocket; Northrop, support contractor; RCA, TV system. DESCRIPTION: Before impact, TV cameras take pictures of lunar surface; ATLAS-AGENA B booster. STATUS: RANGER VI launch Jan. 30; TV system failed; RANGER VII launched July 28 and impacted Moon after transmitting 4,316 pictures back to Earth; RANGER VIII scheduled for first quarter 1965, with IX two months later; this will complete RANGER program.

RELAY (NASA)

TRW Space Technology Laboratories, project coordination and systems planning; RCA, prime. DESCRIPTION: 172-lb. spin-stabilized wideband 800 to 4,600-mi.-orbit active repeater experimental communications satellite; DELTA booster. STATUS: Britain, France, Brazil and Germany building ground stations; first launch, Dec. 13, 1962; RELAY II launched Jan. 21, 1964; program completed.

SAMOS (Air Force Program 720A)

Lockheed, prime; photo intelligence equipment, Eastman Kodak; capsules, GE; parachute and guidance recovery equipment, AVCO and

Northrop Ventura. DESCRIPTION: Reconnaissance satellite; formerly SENTRY; R&D model weighs 4,100 lbs. with E-5 capsule (3,000 lbs. with E-6); ATLAS-AGENA booster; 100-300-mi. circular polar orbit. STATUS: Operational; advanced SAMOS under development; FERRET version used for electronic intelligence and communications eavesdropping.

SATAR (Air Force)

General Dynamics, prime. DESCRIPTION: 300-lb. scientific satellite pod mounted on side of ATLAS booster; length, 55 in.; diameter 27 in.; 200-lb. payload; orbits vary from 500 to 2,000 n. mi.; as re-entry vehicle, gains speeds up to 30,000 fps; guidance, strap-down system with three orthogonally-mounted gyros; unstabilized when in orbit. STATUS: Development; seven vehicles being built under present contract; pods of SATAR type have been flown on 44 missions.

SATELLITE INSPECTOR (Air Force PROGRAM 706)

No contractors announced. DESCRIPTION: Satellite inspection system consisting of a spacecraft capable of co-orbital inspection of non-cooperative satellites. STATUS: Re-oriented from unmanned vehicle to manned satellite using GEMINI; Conceptual preliminary design studies under way; early GEMINI flights expected to provide important inputs; $2 million in FY '65 budget.

SECOR (Army)

ITT Labs, prime; Cubic Corp., transponder. DESCRIPTION: 40-lb. geodetic satellite; rectilinear, measuring 9 x 11 x 14 in.; can be carried piggyback on a variety of boosters; frequency, 162-324 mc for geodetic measurements; 54-216 mc for refraction studies. STATUS: Operational; third launch took place early this year on AF secret satellite; an expanded program at altitudes of 1,800 mi. is being considered.

SERT I (NASA)

RCA, prime. DESCRIPTION: Spinning ballistic test vehicle carrying two electric-propulsion engines for environmental tests. STATUS: First flight July 20 from Wallops Island, Va., carried a Lewis electron bombardment engine and a Hughes contact ionization engine; the Lewis engine worked well while Hughes engine produced no thrust; follow-on flights cancelled since SERT I proved neutralization of an ion beam in space.

START (Air Force)

Award in only one of an expected 10-14 areas has been announced: Martin Co. for work on a vehicle related to the in-house SLV-5. DESCRIPTION: An experimental program, much broader than ASSET, to explore the materials, structures, flight regimes and other areas related to glide atmospheric entry. STATUS: Program package is still being assembled and is not expected to be ready before the end of 1964.

SURVEYOR (NASA)

Hughes, prime; Martin, SNAP device. DESCRIPTION: 2,100-lb. spacecraft for soft-landing 100-300 lbs. of instruments on Moon; nine 2,500-lb. spacecraft are also planned; ATLAS-CENTAUR booster; SNAP nuclear generator optional. STATUS: First Moon flights late 1965; five soft-landing vehicles planned in Block I series.

SYNCOM (NASA)

Hughes, prime. DESCRIPTION: 24-hr. orbit instantaneous narrow band, active repeater communications satellite; 28-in. in dia. and weighs about 63 lbs.; DELTA booster; capable of accommodating one full duplex radio telephone channel. STATUS: First launch failed, Feb. 14, 1963; satellite believed to be in orbit but contact lost; SYNCOM II launched July 26, 1963, completely successful; third launch Aug. 19 successful; satellite, positioned in stationary orbit over Pacific, relayed 1964 Olympic Games to U.S. from Japan; program now complete. DOD may take over satellites for military traffic.

SMS (Synchronous Meteorological Satellite) (NASA)

Republic, RCA Astro-Electronics; Hughes, study contracts. DESCRIPTION: 24-hr. weather satellite, Earth-stabilized; TV cameras with variable focus; may use SNAP-50 for power; booster may be ATLAS-AGENA or -CENTAUR. STATUS: Studies to continue; development funds not included in FY '65 budget; ATS and TIROS K expected to provide major inputs to the program.

TELSTAR (AT&T, NASA)

Bell Telephone Laboratories, management for AT&T. DESCRIPTION: 170-lb. active repeater experimental industry communication satellite; DELTA booster. STATUS: Development; first launch July 10, 1962, highly successful; second launch May 7, 1963, also successful; program now complete.

TIROS (NASA, Weather Bureau)

RCA, prime. DESCRIPTION: 285-lb. meteorological satellite; TV pictures of cloud cover; IR sensors to gather heat balance data; one TIROS to be tested for effectiveness in highly elliptical orbit (300-3,000 mi.) STATUS: R&D; eight satellites launched; all successful; five more launches planned with TIROS wheel configuration (Earth stabilized) to serve as an interim National Operational System.

TRANSIT (NAVY)

Applied Physics Laboratory, prime; Martin, SNAP device; Westinghouse, shipboard satellite signal receivers. DESCRIPTION: Navigational satellite; R&D model over 250 lbs.; operational, 50 to 100 lbs.; operational system; four satellites in random, near-circular 600-mi. orbits; SNAP nuclear generator; ABLESTAR booster. STATUS: Operational system established for use by POLARIS subs and surface ships; two nuclear-powered (SNAP-9A) satellites launched in 1963; NASA exploring feasibility of commercial system.

TRS (Air Force)

TRW/STL. DESCRIPTION: 3-lb. scientific satellite to measure radiation; four-sided, measuring 9 in. on a side. STATUS: Operational; first launched piggyback on DOD payload Oct. 17, 1963.

VOYAGER (NASA)

Study contracts, Avco, GE and Lockheed. DESCRIPTION: Unmanned 7,000 lb. MARINER follow-on spacecraft bus/lander to orbit Mars and eject a capsule to the surface. STATUS: Development funds included in FY '66 budget; RFPs for Preliminary Design Competition to be issued in Jan., 1965; development expected to begin in late 1965 or early 1966; launches in 1971-73 period; spacecraft to be launched by SATURN IB/CENTAUR.

X-15 (NASA, AF, NAVY)

North American, prime; Thiokol, propulsion; Sperry Gyroscope, inertial flight data system; Honeywell, adaptive flight control electronics. DESCRIPTION: Manned rocket plane capable of 4,000-mph plus flight at edge of space; single rocket engine develops 57,000 lbs. thrust. STATUS: Powered flights in progress; unofficial records set—altitude 354,200 ft. and speed 4,104 mph; hypersonic propulsion research program should run through 1968; more than 100 flights have been made; ramjet (X-15A2) flights scheduled for 1968.

Space Vehicles

ABLESTAR (Air Force)

Space General, prime; Aerojet, propulsion; Space General/Bell Telephone, guidance. DESCRIPTION: 2,000-lb. upper stage; 9.5 ft. long; 55 in. dia.; radio command guidance; propellants, UDMH/IRFNA; restart capability. STATUS: Used in TRANSIT and other military programs; THOR booster.

ATLAS-AGENA D (Air Force)

General Dynamics/Aeronautics, (ATLAS); Lockheed (AGENA); TRW/STL, AGENA B; Honeywell, inertial reference. DESCRIPTION: 275,000-lb. booster; payload capability, 5,000 lbs., in 345-mi. orbit, 750 lbs. to escape, length, 102 ft.; base diameter, 10 ft.; liquid propulsion; modified Atlas D with 360,000-lb. thrust; Agena B with 15,000-lb. thrust; restart capability. STATUS: Operational; used in RANGER, DISCOVERER, MILITARY COMSAT, MARINER, LUNAR ORBITER, OAO, SAMOS and other programs.

AGENA D (Air Force)

Lockheed, prime; Honeywell, guidance; Bell, propulsion. DESCRIPTION: 1,700-lb. upper stage; 25 ft. long; 5 ft. dia.; all-inertial guidance; propellants, UDMH/IRFNA; multiple re-start capability; ATLAS, THOR and THOR-augmented boosters. STATUS: Used in DISCOVERER, SAMOS and other military programs as well as a variety of NASA programs; e.g., MARINER, RANGER, OAO and OGO.

CENTAUR (NASA)
Lewis, program management; General Dynamics/Astronautics, prime; Pratt & Whitney, propulsion; Honeywell, guidance. DESCRIPTION: High-energy upper stage using a pair of RL-10 LOX/liquid hydrogen engines; 30,000 lbs. total thrust; 30 ft. long; 10 ft dia.; ATLAS D booster; capable of orbiting 8,500 lbs.; 2,300 lbs. to escape; 1,300 lbs. on planetary flights. STATUS: Development; first test flight failed; second launch Nov. 27, 1963, highly successful; third, June 20, 1964, partially successful; fourth flight successfully launched Dec. 11 and five set for 1965 when the vehicle is to become operational.

DELTA (NASA)
Douglas, prime; Bell Telephone Labs, guidance; Rocketdyne/Aerojet/Allegany Ballistics Laboratory, propulsion. DESCRIPTION: Successor to THOR-ABLE; upper stage guidance; three-stage vehicle; 800-lb. payload capability in 100-mi. orbit; THRUST-AUGMENTED DELTA payload capability 1,500 plus lbs. in 100-mi. orbit; THOR missile comprises first stage. STATUS: launch vehicle for TIROS, EXPLORER, OSO, BIOS, ECHO; TAD used for SYNCOM & PIONEER; 26 previously on order augmented by AF order for 21 more for NASA; THRUST-AUGMENTED DELTA with three solid motor strap-ons also being used.

LITTLE JOE II (NASA)
General Dynamics/Convair, prime. DESCRIPTION: Solid-propelled vehicle with 800,000-lb. thrust; launch vehicles for APOLLO suborbital flights. STATUS: Three launches Aug. 28, 1963, May 13, 1964, Dec. 8, 1964, successful; six vehicles ordered thus far.

POST-SATURN V LAUNCH VEHICLE (formerly NOVA) (NASA)
Under study. DESCRIPTION: Capability of NOVA under study; no firm concept but will be significant improvement over C-5 (20-30 million-lb. first-stage thrust large solid motors, and nuclear upper stage under consideration). STATUS: Study to determine characteristics; operational target date post-1970.

PROJECT FIRE (NASA)
Republic, re-entry package; Ling-Temco-Vought, velocity package; General Dynamics/Astronautics, launch vehicle and systems integration. DESCRIPTION: Re-entry probe to measure environmental heating at lunar return speeds (25,000 mph); launch vehicle, ATLAS D plus Antares II A-5 (re-entry booster). STATUS: R&D; first flight April, 1964, successful; second flight scheduled for mid-1965.

ROVER (NASA, AEC)
Los Alamos Scientific Labs, ROVER prime; Aerojet, NERVA prime; Westinghouse, propulsion. DESCRIPTION: First nuclear rocket; tests of Kiwi, prototype of NERVA engine, under way. STATUS: Kiwi tests completed this year; NERVA tests highly successful; full systems tests of engine now set for fall, 1965—12 months ahead of schedule; development of Phoebus reactor initiated; no flight test program funded at present.

SATURN I (NASA)
Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler Corp.; S-IV, Douglas. DESCRIPTION: Two-stage vehicle for early boilerplate tests of APOLLO and PEGASUS; first stage: eight Rocketdyne H-1 engines; second stage: six Pratt & Whitney RL-10-A3 engines; 22,000 lbs. into 345-mi. orbit. STATUS: Four flight tests of first stage successful; all flights with inert upper stage; first flight with live upper stage successfully launched Jan. 27, putting 37,700 lbs. in low Earth orbit; SA-6 May 28, 1964 and SA-7 Sept. 18, 1964, also successful; three more R&D flights planned to complete development effort.

SATURN IB (NASA)
Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler; S-IVB stage, Douglas. DESCRIPTION: S-1, eight H-1 engines; S-IVB, one J-2 engine; payload capability, 28,500 lbs. in 345-mi. orbit. STATUS: Development; first flight in 1966; boost APOLLO spacecraft boilerplate models, including lunar landing vehicle; first manned flight in APOLLO program set for late 1966; advanced version able to orbit 30 tons under consideration. Booster for VOYAGER with CENTAUR upper stage.

SATURN V (ADVANCED SATURN) (NASA)
Systems engineering, assembly and guidance, Marshall Center; S-IC, Boeing; S-II, North American; S-IVB, Douglas; F-1, North American; J-2, North American. DESCRIPTION: S-IC, five F-1 engines; S-II, five J-2 engines; S-IVB, J-2 engine; 120-ton payload in 345-mi. orbit; 43 tons to escape velocity; 30 tons for planetary missions. STATUS: R&D; first flight scheduled for 1967; prime booster for APOLLO missions; will be used to boost orbiting space station.

SCOUT (NASA)
LTV Astronautics, prime; Honeywell, guidance; Aerojet/Thiokol/Allegany Ballistics Laboratory, propulsion. DESCRIPTION: Solid propulsion four-stage satellite launcher; 72 ft. long; 3.3 ft. dia.; 300-lb. payload in 345-mi. orbit; 80 lbs. to escape. STATUS: Operational; used by NASA for EXPLORER and other small payloads; also procured by NASA for Air Force as BLUE SCOUT; NASA has ordered 23 more boosters.

THOR-ABLE STAR (Air Force)
Douglas, prime; Bell Telephone labs, guidance; Rocketdyne, first-stage propulsion; Space/General, second; DESCRIPTION: Two-stage vehicle with 181,900 lbs. total thrust; performance, 900 lbs., in 100-n.-mi. orbit; length, 55.9 ft., diameter, 8 ft., weight, 118,200 lbs., height, 79 ft.; guidance, radio command; STATUS: Operational; used in TRANSIT and other military program.

THOR-AGENA D (Air Force and NASA)
No prime; Douglas, THOR frame; Lockheed, AGENA D; Rocketdyne, propulsion. DESCRIPTION: Liquid-propulsion vehicle to put 1,600-lb. payload in 300-mi. orbit; length, 76 ft.; diameter, 8 ft.; launch weight, 123,000 lbs.; 172,000 lbs. thrust; THOR, radio guidance, AGENA, all-inertial. STATUS: Operational; used in AF space program; TELSTAR, Topside Sounder and other NASA programs; NASA has 11 launched scheduled.

THRUST-AUGMENTED DELTA (NASA)
Douglas, prime; Thiokol, solid propulsion. DESCRIPTION: DELTA launch vehicle with three strap-on solids; performance, 1,000 lbs. to Earth orbit; 150 lbs. to escape; propulsion, three XM-33 solid motors producing 55,000 lbs. thrust each. STATUS: Development; to be used for BIOSATELLITE, PIONEER, SYNCOM, TIROS COMSAT programs; initial flight in 1964.

THRUST-AUGMENTED THOR (Air Force/NASA)
No prime; Rocketdyne and Thiokol, propulsion. DESCRIPTION: THOR-AGENA with 3 strap-on solids; THOR liquid propulsion, 172,000 lbs. of thrust; each strap-on, 55,000 lbs. thrust; performance, 2,500 lbs. in 100-n.mi. orbit. STATUS: Operational; used for NIMBUS and POGO and others too heavy for THOR, but not heavy enough for ATLAS.

TITIAN II (GLV) (NASA)
Aerospace Corp., systems engineering & technical direction; Martin, prime. DESCRIPTION: Manned space booster; Essentially Titan II with addition of redundant electrical power and flight control systems, malfunction detection system and radio command guidance. STATUS: Development; GT-2 (unmanned version) to be launched in January.

TITAN III (Air Force Program 624A)
Aerospace Corp., systems engineering & technical direction; Martin, systems integration; United Technology, large solid boosters; Martin, TITAN II vehicle; Aerojet, liquid engines; Martin, standardized upper stage; AC Spark Plug, guidance. DESCRIPTION: Quick-reaction vehicle for military space missions; will be used to boost MOL/GEMINI B; Zero stage, two 120-in. solid motors; first and second stages, TITAN II (storable propellants); third-stage standardized vehicle to be developed; modified TITAN II guidance; payload, 25,000 lbs. in 100 n.mi. orbit, 2,100 to 22,300-mi. orbit; 5,000 to escape. STATUS: Development; first flight Sept. 1 (T-IIIA) achieved primary and secondary objectives, but failed to achieve orbit; second flight (T-IIIA) successful Dec. 10; 17 development flights planned; five TITAN II core vehicles (A version), 12 full TITAN III's (C version); nine satellite payloads have been approved for launch during flight test program operational in 1966; an unmanned rated version—TITAN III-X—being studied as more cost/effective booster for satellite launches.

Missiles

AADS-70 (Army)
Hughes/Douglas/FMC, RCA/Beech, competitive component development contracts. DESCRIPTION: Field army ballistic missile defense system, mobile. STATUS: No decision to develop system has been made; component development funded at $5 million in FY '65; expected to provide basis for program definition in 1965.

ADVANCED SURFACE MISSILE SYSTEM (Navy)
Raytheon, Boeing, Sperry Rand, General Electric, Westinghouse, RCA & Hughes, pre-program definition contracts. DESCRIPTION: Fleet air-defense weapon for the 1970 time period; to have capability against aircraft and certain types of air-to-surface missiles; will replace the 3-T systems currently in the fleet. STATUS: Pre-program

definition; program definition planned in mid-1965 and development contract by 1966.

ALFA (RUR-4) (Navy)
Navy, prime; Avco, frame; Naval Propellant Plant, propulsion. DESCRIPTION: ASW, surface-to-underwater; weight, 500 lbs.; solid propulsion; H.E. depth charge; range, 1,000 yds.; guidance, free-flight. STATUS: Operational; deployed on desroyers and cruisers; being replaced by ASROC.

ANTI-SATELLITE WEAPON (Army/Air Force)
Boeing, AF program; Hughes, terminal guidance (IR), AF program; Douglas, THOR and ZEUS vehicles and support services; A. D. Little, Operations Analysis. DESCRIPTION: Consists of both NIKE-ZEUS and THOR-AGENA w/terminal stage programs; intercepts have been accomplished at "hundreds of miles," according to Secretary McNamara. STATUS: Operational according to DOD; however, major portions of the AF program are uncompleted at the Johnston Island test site. RFPs for a follow-on program were to be issued in Dec.

ARM I (Navy)
No contractor announced. DESCRIPTION: Longer-range, smaller anti-radiation missile than SHRIKE for armament of F-111B and A-7A aircraft. STATUS: Advanced development.

ASROC (RUR-5A) (Navy)
Honeywell, prime; Sangamo Electric, sonar, GE, torpedo; Librascope-General Precision, fire control. DESCRIPTION: ASW, surface-to-underwater; weight, 1,000 lbs.; solid propulsion; warhead, nuclear or conventional torpedo; range between 1,800 yds. and 8 mi.; guidance, unguided. STATUS: Operational on DE, DD, DLG, & heavy cruisers; one "live" weapon fired in 1962 Pacific nuclear tests; extended range version in pre-program definition phase; version adaptable to TERRIER launchers being developed.

ASTOR (Mk-45) (Navy)
Westinghouse, prime. DESCRIPTION: Mark 45 ASW, underwater-to-underwater torpedo; weight, over 2,000 lbs.; solid propulsion; warhead, nuclear; range, about 11 n.mi; guidance, wire. STATUS: In production; deployed on hunter-killer submarines.

ATLAS (PGM-15) (Air Force)
TRW Space Technology Laboratories, systems engineering & technical direction; GD/Astronautics, frame; GE/Burroughs/Arma, guidance; Rocketdyne, propulsion; GE/Avco, re-entry vehicle. DESCRIPTION: ICBM; weight, 266,000 lbs.; liquid propulsion; warhead, nuclear; range, 5,500-9,000 mi.; ATLAS "E" and "F" series inertial guidance, ATLAS "D" radio inertial. STATUS: 13 squadrons operational at 11 bases; total number of missiles, 126; phaseout of ATLAS D, E&F's begun and will be completed by April, 1965; ATLAS Standard Launch Vehicle developed for AF space programs; ATLAS launches from WTR being used in conjunction with ATHENA launches at Green River, Utah, in an effort to develop scaling laws for re-entry bodies (Advanced Ballistic Re-entry Systems program).

BOMARC A (AIM-10A) (Air Force)
Boeing, prime; IBM/Westinghouse, guidance; Aerojet/Marquardt, propulsion. DESCRIPTION: Surface-to-air interceptor; weight, 15,000 lbs.; liquid booster/ramjet propulsion; warhead, nuclear; range, 200 n.mi.; guidance, command via SAGE; speed, MACH 2.5; ceiling, over 68,000 ft. STATUS: All A missiles at five bases operational in northeastern U.S. to be phased out by the end of FY 1965; production completed; costs $20 million per year to operate system.

BOMARC B (AIM-10B) (Air Force)
Boeing, prime; General Precision Aerospace/Westinghouse/IBM, guidance; Thiokol/Marquardt, propulsion. DESCRIPTION: Surface-to-air; weight, 16,000 lbs.; solid booster/ramjet propulsion; warhead, nuclear; range, more than 400 n.mi.; guidance, command via SAGE; speed, Mach 2.7. STATUS: Three bases operational production completed; the 188 B models will be distributed among the eight bases after the A model is phased out.

BULLPUP (AGM-12 B & C) (Navy-Air Force)
Martin, systems cognizance; Maxson Electronics Co., production; AMF, liquid engine; Thiokol, solid propulsion; Naval Propellant Plant, solid propulsion (motor loading). DESCRIPTION: Air-to-surface; range, 3-6 mi.; guidance (visual reference), radio-link command. BULLPUP A: Solid propulsion; warhead, 250-lb. H.E. BULLPUP B: pre-packaged liquid motor; warhead, 1,000-lb. H.E. STATUS: BULLPUP A deployed with Atlantic and Pacific Fleets; operational with U.S. Air Force & NATO units; training version (ATM-12) being procured by both services; being produced in Europe for NATO.

CLOSE-SUPPORT ASSAULT WEAPON (Navy)
Navy Bureau of Weapons and Johns Hopkins Applied Physics Lab, prime; United Aircraft Norden Div., guidance. DESCRIPTION: Ship-to-shore; outside dimensions compatible with TERRIER shipboard installations; solid propulsion; warhead, high explosive; range, 30-mi. minimum; guidance, inertial and terminal. STATUS: Carried as a line item in FY '66 budget; gyro packages for flight test delivered by Norden; funding dependent on results of guidance system flight tests at WSMR aboard SERGEANT missiles.

CONDOR (AGM-53) (Navy)
In-house project, Naval Ordnance Test Station; RFP's issued to nine firms; Martin, Douglas, McDonnell, Hughes, NAA-Columbus, Northrop, Raytheon, Grumman & Bendix. DESCRIPTION: Air-to-surface; configuration classified. STATUS: Development; intended for use with Navy version of F-111.

DAVY CROCKET (M-388) (Army)
In-house project directed by Army Weapons Command at Rock Island, Ill. DESCRIPTION: Surface-to-surface; solid propulsion, bazooka-launched; warhead, subkiloton nuclear; guidance, free flight; two launchers — vehicle-mounted or carried by two men. STATUS: Operational in Europe; $13 million provided in FY '64 budget; 3 per ROAD battalion; seen as defensive rather than offensive weapon to prevent overrun of Europe.

ENTAC (MGM-32) (Army)
Nord Aviation, prime. DESCRIPTION: Anti-tank; weight, 37 lbs. with launcher; solid propulsion; warhead, shaped-charge H.E.; range, 6,600 ft.; guidance, wire-guided; man-portable. STATUS: Operational; procurement complete; will be replaced by TOW.

FALCON (AIM-4 A, C, E, F/26A/47A) (Air Force)
Hughes, prime; Hughes, guidance; Thiokol, AIM-4/26 propulsion; Lockheed Propulsion, AIM-47 propulsion. DESCRIPTION: Air-to-air; weight (AIM-4/47), more than 100 lbs. — (AIM-26), more than 200 lbs.; range 5 n.mi.; supersonic; solid propulsion; warhead, H.E. (except for AIM-26); AIM-4A, and 4E, active radar homing guidance; AIM-4C, and 4F, IR homing; AIM-26 model has nuclear warhead and hybrid IR radar homing. STATUS: Operational buy-out of 4E, 4F and 26 in FY '62; AIM-47 is the armament for YF-12A (A-11).

GENIE (AIR-2A) (Air Force)
Douglas, prime; Aerojet-General, propulsion. DESCRIPTION: Air-to-air; weight 800 lbs.; unguided; solid propulsion; warhead, nuclear; range, 6 n.mi.; guidance, free flight; supersonic; proximity fuzing. STATUS: Procurement complete; operational on F-101B and F-106; improved version cancelled.

HAWK (MIM-23A) (Army)
Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion. DESCRIPTION: Surface-to-air; weight, 1,275 lbs.; solid propulsion; warhead, H.E.; range, 22 mi.; guidance, semiactive radar homing; 100-45,000-ft. ceiling; provides defense against medium and low-flying aircraft and cruise-type missiles. STATUS: Operational, deployed in Europe, Panama, Okinawa, U.S. (13 battalions); bought by Sweden and Israel; R&D being conducted to adapt selected HAWK units to an anti-tactical ballistic missile; NATO producing; Japan also plans buy.

HIBEX (ARPA/Army)
Boeing, prime; Hercules and Aerojet, propulsion. DESCRIPTION: Experimental program in high-energy propellants; cone shaped missile; performance classified; solid propulsion. STATUS: Development; accelerations of 800 to 1,000 g's goal; static test of motor successful, Nov. 1964; flight test program of 10 vehicles to be conducted at WSMR beginning late this year.

HONEST JOHN (MGR-1) (Army)
Douglas/Emerson Electric, prime; Hercules, propulsion. DESCRIPTION: Surface-to-surface; weight, 5,900 lbs.; single-stage solid propulsion; warhead, nuclear; range, 12 mi. (M-31), 20 mi. (M-50); unguided. STATUS: Operational; M-50 being deployed in Europe; to be replaced by LANCE; procurement complete.

HOUND DOG (AGM-28) (Air Force)
North American, prime; Autonetics, guidance; Pratt & Whitney, propulsion. DESCRIPTION: Air-breathing air-to-surface standoff missile; weight, 9,600 lbs.; turbojet propulsion; warhead, nuclear; range, about 600 n.mi.; guidance, all-inertial; ceiling in excess of 50,000 ft.; Mach 2+. STATUS: Operational; to be launched from B-52G intercontinental bombers; procurement complete.

LANCE (XMGM-52) (Army)
Ling-Temco-Vought, prime; Systron-Donner, guidance. DESCRIPTION: Highly mobile general-purpose missile; very light weight; pre-packaged storable liquid propellant; warhead, nuclear and H.E.; range, 3-30 mi.; guidance, Automet inertial, one missile per launcher. STATUS: Large-scale development; eventually will replace HONEST JOHN and LACROSSE and perhaps LITTLE JOHN; division support weapon; to use multi-system test equipment.

LITTLE JOHN (MGR-3) (Army)
Emerson Electric, prime; Hercules Powder, propulsion. DESCRIPTION: Surface-to-surface; weight, 800 lbs.; solid propulsion; warhead, nuclear; range, 10-mi.; unguided; supplements medium and heavy artillery in airborne divisions and air-transportable commands. STATUS: Two battalions activated in 1961; each equipped with four launchers; air and helicopter transportable; may be replaced by LANCE.

M72 (Army)

Hesse/Eastern Div., Flightex Fabrics, prime. DESCRIPTION: Light anti-tank rocket; weight, 4.5 lbs.; solid propulsion; warhead, H.E.; range, 500 yds.; guidance, free flight, carrier tube launcher; earlier called LAW. STATUS: Operational.

MACE (MGM-13A, CGM-13B) (Air Force)

Martin, prime; Goodyear/AC Spark Plug, guidance, Thiokol/Allison, propulsion. DESCRIPTION: Air-breathing surface-to-surface; weight, 18,000 lbs.; turbojet and solid propulsion; warhead, nuclear and H.E., range, over 650 n.mi. (Model A), over 1,200 n.mi. (Model B); guidance, Map-matching (A), Inertial (B). STATUS: Five MACE-A and one MACE-B squadron (in hard sites) deployed in Europe; two MACE-B squadrons on Okinawa in hard sites.

MAULER (MIN-46) (Army)

GD/Pomona, prime; Hughes, guidance; Lockheed, propulsion; deHavilland, IR acquisition; Raytheon, radar; Burroughs, computer; FMC, carrier vehicle. DESCRIPTION: Surface-to-air; weight, 120 lbs.; solid propulsion; warhead, nuclear, H.E.; guidance, IR acquisition; highly mobile anti-aircraft and anti-missile missile; tracked vehicle; 9 missiles per launcher. STATUS: Development; suffering serious packaging problems: Army postponing more advanced models until after feasibility validation program has determined if system can be saved.

MAW (Army)

McDonnell Aircraft Co. and Army Missile Command, development of competitive approaches to Medium Anti-Tank/Assault Weapon requirement; Ford Instrument Co., gyro package for Army version. DESCRIPTION: Surface-to-surface; solid propellant; range, 500-1,500 yds.; shoulder-fired; McDonnell version wire-guided; Army version two-degree-of-freedom, free rotor gyro. STATUS: Exploratory Development; competitive approaches to be fired off against each other in Summer, 1965, using a ZUNI test vehicle, and the best allowed to proceed into full-scale development.

MINUTEMAN (LGM-30) (Air Force)

TRW Space Technology Laboratories, systems engineering and technical direction; Boeing, major contractor; Autonetics, guidance; Thiokol, first-stage propulsion; Aerojet, second-stage propulsion; Hercules, third-stage propulsion; Avco, re-entry vehicle. DESCRIPTION: 2nd-generation ICBM; weight, over 65,000 lbs.; solid propulsion; warhead, nuclear; 3 stages; range, over 5,000 mi.; guidance, all-inertial, target selected in seconds; 32-sec. reaction time. STATUS: MINUTEMAN II flight-test program (36 shots planned) began Sept. 24; over 700 MINUTEMAN I now operational; 1,000 missiles through FY '65; advanced version can be fired by airborne command posts; deployed in hardened and dispersed silos; MINUTEMAN II expected operational 1965, to be co-located with MMI; also some of the II's replace earlier models; MMII has greater accuracy and range/payload than I version.

NIKE-HERCULES (MIM-14B) (Army)

Western Electric, prime; Western Electric, guidance; Hercules and Thiokol, propulsion; Douglas, airframe. DESCRIPTION: Surface-to-air, antiaircraft, tactical; weight, 10,000 lbs.; solid propulsion; warhead, nuclear or H.E.; range, 75 mi.; guidance, command; Mach 3+; ceiling in excess of 150,000 ft. STATUS: Over 80 batteries deployed in U.S. being turned over to National Guard; over 10 N-H batteries deployed overseas; Japan plans additional procurement; being equipped with HIPAR, a high power acquisition radar, and anti-tactical-ballistic-missile capabilities. Re-location of some Hercules batteries under consideration by JCS.

NIKE-X/Zeus (XLIM-49) (Army)

Western Electric, prime; Bell Telephone, guidance; Thiokol/Lockheed, propulsion; Douglas, airframe. DESCRIPTION: Antimissile missile, 3-stage; weight, 22,800 lbs.; solid propulsion; warhead, nuclear; range, 200-mi.; guidance, command; length, 48 ft.; diameter, 36 in.; fin span, 10 ft. STATUS: Missile is now part of NIKE-X missile "mix"; development, except as part of X, has ended; no intercept "failure" in more than a year of tests.

NIKE-X (Army)

Western Electric, prime; Bell Telephone, guidance; Thiokol, ZEUS propulsion; Douglas, ZEUS airframe; Martin Marietta, SPRINT missile prime; Hercules and Lockheed, SPRINT propulsion. DESCRIPTION: Successor to ZEUS as an anti-ICBM system; uses a mix of ZEUS/SPRINT missiles and multi-function array radar (MAR). STATUS: Engineering development; funded at $334 million in FY '65 on accelerated development schedule, but deployment still deferred; tests to be conducted late this year with MAR at WSMR, New Mexico, could provide basis for deployment decision; deployment cost: $12-20 billion.

PERSHING (MGM-31) (Army)

Martin, prime; Bendix guidance; Sperry Farragut, fuzing and aiming; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; two-stage solid propulsion; warhead, nuclear; range, approx. 400 n.mi.; guidance, inertial; transported on FMC M474 tracked vehicles; replaced REDSTONE. STATUS: Flight test program completed; troop firings from Ft. Wingate, N.M., to White Sands being conducted; number of missile-loaded launchers per unit to be increased; West Germany organizing two battalions; first U.S. PERSHING battalion deployed to Germany in April.

PHOENIX (AIM-54) (Navy)

Hughes Aircraft Co., prime; Rocketdyne, propulsion. DESCRIPTION: Air-to-air missile for use with the F-111B fighter aircraft; each aircraft will be able to carry six missiles. STATUS: Development. $25 million overrun may force program stretchout.

POLARIS (UGM-27 A, B, C) (Navy)

Lockheed, prime; GE/MIT/Hughes/Honeywell/Raytheon, guidance and fire control; Aerojet-General/Hercules, propulsion; Lockheed, re-entry vehicle; Nortronics, checkout; Autonetics/Sperry, SINS; Westinghouse, launching equipment; Vitro, systems engineering co-ordination and training; Systron-Donner, ignition programming. DESCRIPTION: Underwater- and surface-to-surface; weight, 30,000 lbs.; solid propulsion; warhead, nuclear; range, 1,200 n.mi. (A-1), 1,500 n.mi. (A-2), 2,500 n.mi. (A-3); guidance, all-inertial STATUS: 19 subs operational each with 16 missiles; A-1 aboard first five submarines; A-2 aboard subs 6-18; A-3, operational in August, 1964, aboard subs 19-41; total of 41 POLARIS subs authorized; deployed in Atlantic and Mediterranean; Pacific deployment to begin by end of year; British to buy A-3 missiles from U.S. B-3 program definition included in FY '65 budget; missile for NATO MLF surface force concept.

QUAIL (ADM-20C) (Air Force)

McDonnell, prime; McDonnell Electronics, guidance; GE, propulsion; Thompson Ramo Wooldridge, ECM equipment. DESCRIPTION: ECM-carrying decoy which simulates B-52 bomber to enemy radar; turbojet powered; range, 250 mi.; guidance, gyroscopic autopilot. STATUS: Deployed at SAC bases; carried by B-52; procurement completed FY '61; advanced version with 400-mi.-range has been flight tested.

REDEYE (MIM-43) (Army)

GD/Pomona, prime; Hughes, IR seeker; Atlantic Research, propulsion. DESCRIPTION: Surface-to-air; weight, 22 lbs.; solid propulsion; warhead conventional; guidance, IR-homing; length, 44 in.; diameter, 2.75 in. STATUS: Development to continue; Congress denied FY '65 procurement request; tests against helicopters and jets at NOTS successful.

REGULUS I (RGM-6) (Navy)

Ling-Temco-Vought prime; Sperry, guidance; Allison, propulsion. DESCRIPTION: Surface-to-surface; weight, 14,000 lbs.; turbojet and solid propulsion; warhead, nuclear; range, 500 n.mi.; guidance, inertial; speed, about 600 mph; ceiling, approx. 40,000 ft. STATUS: Five REGULUS subs with 17 missiles are operational now; 3 subs (8 missiles) will be phased out in FY '65.

SERGEANT (MGM-29A) (Army)

Sperry Utah, prime; Sperry, guidance; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; solid propulsion; warhead, nuclear; range, over 75 n.mi.; guidance, inertial; uses drag brakes. STATUS: Operational; procurement complete; deployed in Europe; replacement for CORPORAL; West Germany buying system.

SHILLELAGH (MGM-51A) (Army)

Philco Aeronautronic, prime Picatinny Arsenal/Amoco Chemicals Corp., propulsion; Aeronautronic, guidance. DESCRIPTION: Surface-to-surface; lightweight; solid propulsion; warhead, nuclear or H.E.; guidance, command; vehicle-mounted for use against field fortifications, armor and for close-in support of troops. STATUS: Production. Initial procurement in FY '65; to use multi-system test equipment; engineering development stage began in FY '64; to be installed on Gen. Sheridan assault vehicle; also being considered for use on helicopters.

SHRIKE (AGM-45A) (Navy)

Naval Ordnance Test Station-China Lake, prime; Texas Instruments, guidance and control; North American Rocketdyne (McGregor), propulsion. DESCRIPTION: Air-to-surface, anti-radar; solid propulsion; guidance, passive radar homing. STATUS: Operational; armament for Navy and Air Force tactical aircraft.

SIDEWINDER I-C (AIM-9D) (Navy, Air Force)

Naval Ordnance Test Station, technical direction; Philco, guidance; Naval Ammunition Depot, McAllister, motor loading; Rocketdyne (McGregor), propellant. DESCRIPTION: Air-to-air; weight, about 155 lbs.; solid propulsion; warhead, H.E.; range, more than 2 mi.; guidance, IR. STATUS: 1A deployed with Navy and Air Force; 1-C version being procured as replacement for 1A; NATO-built version now in production.

SPARROW III-6B (AIM-7E) (Navy)

Raytheon, prime; Raytheon, airframe, control, guidance; Aerojet-General/North American Rocketdyne (McGregor), propulsion; McDonnell/Benrus Watch Co., launcher. DESCRIPTION: Air-to-air; weight, 350 lbs.; solid propulsion; warhead, conventional; range, 5-8 mi.; guidance, semi-active CW homing; Mach 2.5-3; ceiling, over 50,000 ft. STATUS: Earlier models operational with carrier aircraft; SPARROW III-6B prime armament for Phantom II (F-4B) and other high-performance interceptors; British F-4 buy expected to include SPARROW missiles.

SPRINT (Army)
Martin-Orlando, prime; Hercules Powder/Lockheed Propulsion Co., propulsion; Bell Telephone Laboratories, guidance. DESCRIPTION: High-acceleration cone-shaped missile for low-altitude interception of ballistic missiles; 4.5-ft. base diameter, 27 ft. long; two stage; nuclear; missile will be popped out of silo before motor is ignited; to be part of the missile mix in a NIKE-X battery. STATUS: Development; SQUIRT vehicle to be used to test materials and components for SPRINT at White Sands Missile Range; pop-up tests to prove silo ejection concept and mechanism under way at Martin-Orlando plant.

SRAM (Air Force)
No contractors selected. DESCRIPTION: Air-to-surface defense-suppression missile for use with the B-52, B-58 or the Advanced Manned Strategic Aircraft. STATUS: Advanced development.

STANDARIZED MISSILE (Navy)
No contractors. DESCRIPTION: Fleet air-defense missile to replace TARTAR-TERRIER and give Navy a single missile to perform both missions; longer-range targets would be engaged by adding a booster to the shorter-range weapon; similar to the homing TERRIER now being procured. STATUS: Development; expected to be procured initially in 1967-68.

SUBROC (UUM-44A) (Navy)
Naval Ordnance Laboratory, technical direction; Goodyear, prime; General Precision Aerospace, guidance; Thiokol, propulsion; General Precision Librascope, fire control. DESCRIPTION: Underwater-air-underwater antisubmarine missile depth bomb; solid propulsion; warhead, nuclear; weight, 4,000 lbs.; length, 21 ft.; diameter, 21 in.; range, 25-30 mi.; guidance, inertial. STATUS: Production scheduled for installation in Thresher-class subs; operational evaluation under way.

SS-10 (Army)
Nord Aviation, prime; GE, U.S. licensee. DESCRIPTION: Surface-to-surface, primarily antitank; weight, 33 lbs.; solid propulsion; warhead, conventional; range, 1,600 yards; wire guided. STATUS: Operational with U.S., French and other NATO and Western units; battle-tested in North Africa; U.S. replacing with ENTAC.

SS-11 (Army)
Nord Aviation, prime. DESCRIPTION: Surface-to-surface antitank, also helicopter-to-surface; weight, 63 lbs.; solid propulsion; wire guided; warhead, conventional; range, 3,800 yds. STATUS: Operational, to be used with airborne units and Army helicopters.

TACTICAL PROBE (Navy)
Bendix, prime: DESCRIPTION: Surface-to-air; multiple, interchangeable payloads for each mission; booster, TERRIER or TALOS from shipboard installations; high-impulse second stage; range, 50-300 mi.; parachute descent. STATUS: Program definition; a new study has been authorized, and is under way, to evolve a cheaper program.

TALOS (RIM-8E) (Navy)
Bendix, prime; Vitro, systems engineering; McDonnell/Hercules Allegany Ballistics Lab., propulsion; Sperry, guidance; GE, launching gear. DESCRIPTION: Ship-to-air; weight, 7,000 lbs.; solid and ramjet propulsion; warhead, nuclear; range, 65 n.mi.; guidance, radar beam riding/semi-active homing; Mach 2.5. STATUS: Operational aboard cruisers Galveston, Little Rock & Oklahoma City and three Albany-class DEG's; Long Beach, nuclear-powered cruiser, has advanced TALOS; "3-T" get-well program increasing reliability.

TARTAR (RIM-24B) (Navy)
Vitro, systems coordination engineering; Applied Physics Lab, design and development; GD/Pomona, assembly and test; Raytheon, guidance; Aerojet-General, propulsion (motor loading); Sperry Farragut, fuze (target detection device). DESCRIPTION: Ship-to-air; weight, 1,500 lbs.; solid dual-thrust motor; warhead, conventional; range, 10 n.mi.; guidance, beam-riding; Mach 2. STATUS: Operational; installed aboard 27 guided missile destroyers and one cruiser equipped with TALOS; get-well program progressing satisfactorily; CVA Kennedy will also have TARTAR.

TERRIER (RIM-2E) (Navy)
Vitro, systems engineering; GD/Pomona, prime; GD/Pomona, guidance section; Sperry, radar; Hercules Allegany Ballistics Laboratory, propulsion; Northern Ordnance, launching gear. DESCRIPTION: Ship-to-air; weight, 3,000 lbs.; 27 ft. long; solid propulsion; warhead, conventional; range 10 n.mi.; guidance, radar beam-riding or homing; Mach 2.5. STATUS: Operational aboard two attack carriers, 6 cruisers, and 12 missile frigates; get-well program progressing satisfactorily.

TITAN I (HGM-25A) (Air Force)
TRW Space Technology Laboratories, systems engineering and technical direction; Martin, prime; Bell/Sperry, guidance; Aerojet-General, propulsion; Avco, re-entry vehicle. DESCRIPTION: ICBM; weight, 220,000 lbs.; LOX/RP-1 fueled; warhead, nuclear; range, 5,000 mi.; guidance, radio inertial; 90 ft. long; 2 stages. STATUS: Operational; 54 missiles at 5 bases. All will be deactivated by July, 1965.

TITAN II (LGM-25C) (Air Force)
Martin, prime; TRW Space Technology Laboratories, system engineering and technical direction; AC Spark Plug, guidance; Aerojet-General, propulsion; GE, re-entry vehicle. DESCRIPTION: ICBM; weight, 330,000 lbs.; N_2O_4 and Aerozine-50 storable fuels; warhead, nuclear; range, over 5,000 mi.; guidance, inertial; 115 ft. long; 2 stages; greatest payload and range of any U.S. ICBM; basic core vehicle for TITAN III booster. STATUS: All 54 missiles operational; one squadron (18 missiles) operational at Davis-Monthan AFB; one (18 missiles) at McConnel AFB and one (18 missiles) at Little Rock AFB.

TMRBM (Air Force)
No contractors announced, but likely to be the same team producing the second and third stages of MINUTEMAN II. DESCRIPTION: A transportable mid-range missile to fill the gap left by cancellation of MMRBM; it would use the top two stages of MM II and the MM II guidance system; would weigh more and be less mobile than MMRBM, but could be developed for approximately one-third the cost; reaction time also less than MMRBM's; employment concept much the same as that of the Russian-deployed missiles in Cuba in 1962. STATUS: Study by the Air Force at DDR&E direction; not likely to be developed due to a lack of mission.

TOW (Army)
Hughes, prime. DESCRIPTION: Antitank; weight, 160 lbs.; solid propulsion; warhead, H.E.; wire guided; optically tracked; tube-launched. STATUS: Development; follow-on to ENTAC; firings being conducted at Army Missile Command.

WALLEYE (Navy)
Naval Ordnance Test Station-China Lake. Navy is negotiating PDP contracts with Martin, NAA & Hughes. DESCRIPTION: Guided air-to-surface bomb; weight, 1,000 lbs., equipped with movable fins; propulsion type, none; warhead, high-explosive; range, several miles; guidance, TV contrast homing guided by pilot. STATUS; Engineering development; two production contracts will be awarded as well as one for additional development.

ZUNI (Navy)
Naval Ordnance Test Station, prime; Hunter-Douglas, propulsion. DESCRIPTION: air-to-surface; weight, 107 lbs.; solid propulsion; warhead, conventional; range, 5 n.mi.; unguided; STATUS: Operational; designed for use on jet fighter and attack aircraft.

ORDER REPRINTS OF THE ASTROLOG FROM:

Research Department

Missiles and Rockets
1001 Vermont Avenue, N.W.
Washington, D. C. 20005

Price: 35 cents per copy. Payment must accompany order.

Think of the best buy you ever made in accelerometers. It was probably the Donner 4310. (We've built more tha 12,000 to date.) Now think of a new accelerometer one-third the size, and two-thirds the weight with all the good specs of the Donner 4310 plus the virtue of withstanding 35 G's vibration and 200 G's shock. That's something to think about. It's the new S-D 5410 Non-Pendulous Accelerometer. You write, we'll send full details.

ACCELEROMETER
SER. NO
DONNER
CONCORD, CALIFORNIA

Actual Size
Weight: 3 ounces

Systron-Donner's New Non-pendulous Accelerometer Model 5410 features high output, high resolution and high accuracy in environments of high acceleration, shock and vibration. A *pure translational* accelerometer which meets or exceeds all pertinent MIL specs, the 5410 achieves exceptionally rugged performance through use of a non-pendulous flexure suspended seismic mechanism. This new accelerometer is specified and qualified for the SATURN V Program.

SYSTRON DONNER
CORPORATION
888 Galindo Street • Concord, California

Circle No. 6 on Subscriber Service Card

New Gyros Being Sought for MORL

Control moment units seen as key to stabilization, SCS economy; research model to be developed; details of MORL SCS

by Michael Getler

HAMPTON, VA.—Development of new, large, and highly accurate control moment gyros (CMG's)—a key component for stabilization and control systems (SCS) applicable to future NASA space-station concepts—will take an important step forward this month with initiation of a competition for a research model gyro development effort.

Engineers at NASA's Langely Research Center here, attempting to optimize design of the space agency's *Manned Orbital Research Laboratory (MORL)* concept, told MISSILES AND ROCKETS that RFP's for the new gyro will be issued later this month, and a contractor selected for the 12-month development effort about two months after the RFP's are issued.

Studies of the *MORL* concept have recommended use of this type of gyro in a momentum-storage stabilization system combined with a reaction control system (RCS).

Analysis has shown that the major torque-producing forces acting upon an *MORL* in the missions for which it is primarily being designed—gravity-gradient forces which vary with altitude and attitude, aerodynamic forces generated in the low-density Earth-orbit environment, and torques generated by operation of the on-board centrifuge—tend to be cyclical, changing directions periodically. Therefore, scientists point out, a momentum-storage system can be used to store the impulses generated by these torques during one half of the *MORL* cycle, releasing them during the second half. This yields a significant saving in the amount of on-board RCS propellant required for attitude corrections.

Although CMG's have been developed for other programs, and have been under study at Langley for the past three years, the size and accuracy requirements for *MORL* mark the gyro as a significant new development area.

The *MORL* CMG's reportedly will be larger than any other gyro of this type thus far developed for space systems (though not larger than some which have been developed for submarine use). Primary effort is expected to be directed at scaling smaller systems to *MORL* size, which may require new fabrication methods. CMG's will account for a major portion of the *MORL* SCS weight and power.

Development of the *MORL* SCS concept is being undertaken as part of the broad *MORL* optimization program being carried out for NASA by Douglas Aircraft Co.'s Missile & Space Systems Div. On Dec. 1, Douglas completed Phase IIa of the *MORL* project and turned in a 27-volume report to NASA (M/R, Nov. 30, p. 60).

Supporting the Douglas effort on *MORL* in the SCS area is Bendix Corp.'s Eclipse-Pioneer Div. While Bendix has contributed heavily to the design of the entire SCS, important work on early definition of CMG design has also been carried out by the Garrett Corp., as an advanced technology effort supported by Langley. Garrett work will also aid NASA in shaping specifications for the upcoming CMG prototype contract.

• **Lab hardware sought**—Project engineers here stress that the pending development effort will be aimed strictly at obtaining laboratory hardware for a wide range of planned ground testing. While the project is expected to have a direct bearing on the type of CMG's used aboard any future *MORL* stations, the research model will have somewhat different performance characteristics, to allow a broad study of CMG characteristics and evaluations of its possible use in other roles, and to avoid imposing difficult scaling problems on a new CMG test set-up being planned for Langley.

NASA, supported by Sperry Rand's Systems Group, is now attempting to define a new facility here for full-scale testing with these gyros. This will involve a new flight-control test simulator in which the vehicle control system is mounted on a three-gimbal servo table and linked to a computer.

Engineers are anxious to gather data on such parameters as CMG cross-coupling effects, relationships between input and output torques, and the accuracies to which CMG gimbals can be driven.

The research-model CMG will be of the double-gimbal variety, is expected to weigh about 95 lbs., have about a 2-3 ft. diameter, and have an angular momentum of about 1,000 ft.-lb.-sec. The double-gimbal gyros being studied in the *MORL* role will be of roughly the same physical dimensions but with somewhat smaller angular momentum figures (550 ft.-lb.-sec.).

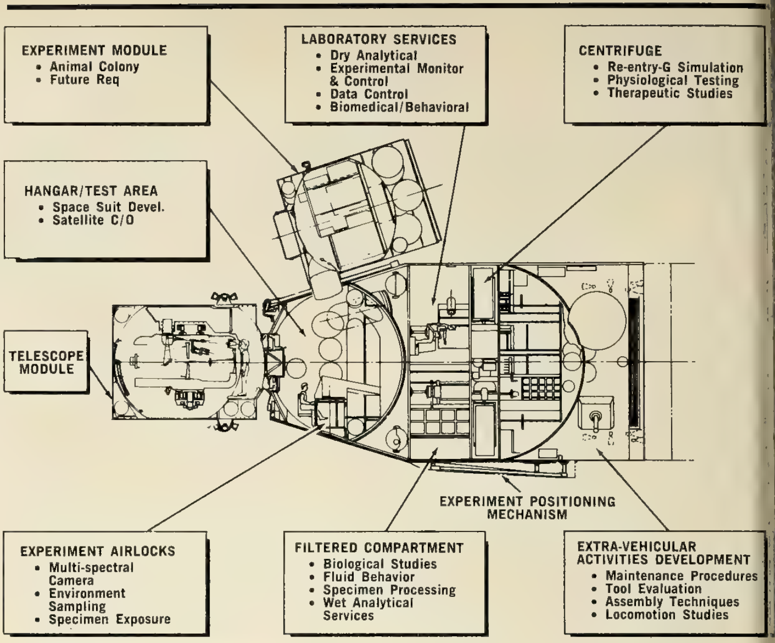
If CMG's with dimensions and accuracies amenable to space station use are shown to be feasible, engineers here feel they will be a strong contender for inclusion in other large rotating space-station concepts under study, such as the 24-36-man *Large Orbital Research Laboratory (LORL)* under study at the Manned Spaceflight Center in Houston, and also perhaps for some of the smaller systems concepts such as NASA's *Apollo-X* program and the Air Force's *Manned Orbiting Laboratory (MOL)* project.

While these smaller systems do not use a CMG-based system, engineers suggest that increased stabilization system requirements to meet possible future on-board experiment objectives could increase interest in including this type of system.

MORL is only one of three space station concepts now under study within NASA, and is not an approved program. However, the type of space station embodied by the *MORL* concept, in which 6-9 men can be placed in a variety of Earth, lunar, and synchronous-altitude orbits using existing *Saturn IB* and *V* launch vehicles and achieving station lifetimes to five years, is known to have considerable support as a very reasonable approach to future use of relatively large stations.

• **MORL SCS details**—the *MORL* SCS is being designed as a single system operating in both the zero-g and artificial-g flight modes which will be possible with *MORL*.

Rotating artificial-g mode is accomplished through a unique deployable cabling scheme in which the expended *Saturn* S-IVB stage (common to both *Saturn IB* and *Saturn V* launch vehicles)


EXPERIMENT MODULE
• Animal Colony
• Future Req
LABORATORY SERVICES
• Dry Analytical
• Experimental Monitor & Control
• Data Control
• Biomedical/Behavioral
CENTRIFUGE
• Re-entry-G Simulation
• Physiological Testing
• Therapeutic Studies
HANGAR/TEST AREA
• Space Suit Devel.
• Satellite C/O
TELESCOPE MODULE
EXPERIMENT POSITIONING MECHANISM
EXPERIMENT AIRLOCKS
• Multi-spectral Camera
• Environment Sampling
• Specimen Exposure
FILTERED COMPARTMENT
• Biological Studies
• Fluid Behavior
• Specimen Processing
• Wet Analytical Services
EXTRA-VEHICULAR ACTIVITIES DEVELOPMENT
• Maintenance Procedures
• Tool Evaluation
• Assembly Techniques
• Locomotion Studies

PRELIMINARY LAYOUT of MORL included in recent Douglas report.

is extended from the *MORL* module to a maximum distance of about 150 ft. and attached to the *MORL* by eight connecting cables. The entire *MORL*-S-IVB arrangement is then spun in orbit by RCS jets, achieving up to a 0.6-g environment in the station.

Although low-altitude polar orbits and low-inclination synchronous orbits are now being considered for *MORL*, the primary "baseline" mission for which the system is being studied involves launch with a *Saturn IB* into a low-inclination (40-50 deg) 200-n.-mi. Earth orbit. At least the initial mission will be performed in the zero-g non-rotating mode, and follow-on operations will be influenced by results of that flight.

Also, scientists here point out that a so-called 30-day biomedical reference point for zero-g operation is expected to be gained from either the *Apollo-X* or AF *MOL* programs prior to *MORL* operation in the 1970 period.

If 30-day zero-g operations are successfully accomplished, it is felt, 45-day stay-times aboard a non-rotating *MORL* may prove to be feasible through onboard solutions to the extended weightlessness conditions, possibly with periodic conditioning in the on-board centrifuge. This device will be capable of producing up to 9 g's for crew simulations prior to re-entry.

The basic *MORL* SCS system consists of attitude-reference elements, the momentum-storage system, a reaction control system, and an alternate inertial reference package for manual operation during some maneuvers. Also expected to be included are various attitude-reference sensor improvements and laboratory-experiment isolation gimbaling schemes to handle the small number of experiments demanding extreme stabilization accuracies.

The basic attitude-reference elements include inertial rate integrating gyro (IRIG's), and Earth and Sun sensors for aligning the inertial reference. A solar detector is used to acquire the Sun, and wide- and narrow-angle sensors monitor laboratory attitude. The Earth-horizon scanner will provide local vertical.

Engineers point out that the horizon scanner is another area which might require at least a demonstration program —the accuracies quoted for the device are based mostly upon modification of existing scanners and projections from ground laboratory tests.

Signals from these sensors and the IRIG's are used, NASA says, to select the appropriate actuator logic for the momentum-storage system and RCS.

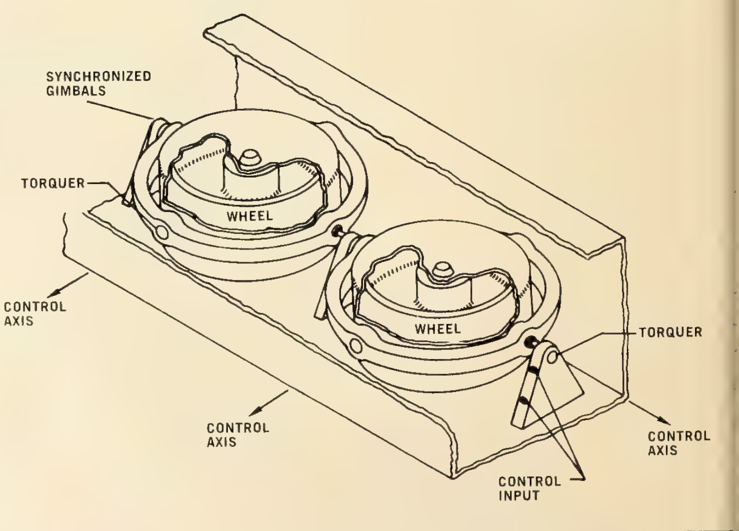
- **CMG operation**—An evaluation of the various techniques for the momentum-storage system thus far has yielded a recommended configuration for zero-g operation which consists of two single-gimbal CMG's controlling the *MORL* X-axis and two double-gimbal CMG's controlling the cyclic torques about the Y and Z axes. Details of this design must be defined, but this basic scheme, Douglas and Bendix studies indicate, was chosen as optimum because of its weight, power, volume, and relative mechanization simplicity.

For artificial-g operation aboard *MORL*, the single-gimbal units are precessed to the Y-axis to act as wobble dampers and compensate for the effects of crew motion and other applied torques.

Each of the single-gimbal gyros will have an angular momentum capability of 1,800 ft.-lb.-sec. and each of the double-gimbal units will have a 550-ft.-lb.-sec. capability. Gimbal stops of 60-deg. will be included to avoid gimbal lock problems.

A CMG employs a constant-speed wheel mounted in either a one- or two-gimbal frame. The control torque is a

SIMPLIFIED SKETCH of a twin double-gimbal control moment gyro.


SYNCHRONIZED GIMBALS
TORQUER
WHEEL
CONTROL AXIS
WHEEL
TORQUER
CONTROL AXIS
CONTROL AXIS
CONTROL INPUT

function of the rate of change of the wheel momentum component along the axis being controlled and is generated by gimbal torquers that precess the momentum vector of the wheel.

One of the areas that NASA engineers here will look at with the prototype CMG is possible improvement in the means of torquing the CMG. For example, it is felt that alternate torquing of a double-gimbal system, by locking one gimbal and then applying a torque to the other, might lead to use of double-gimbal units which can act as a single gimbal, thereby saving power while retaining the flexibility inherent in a two-gimbal design.

According to the Phase IIa evaluation of the CMG design, CMG wheel speed studies resulted in a synchronous speed of 12,000 rpm. The material selected is centrifugally cast titanium alloy.

The *MORL* RCS consists of 16 50-lb. thrusters for attitude control, using storable, hypergolic bipropellants. Also included will be four 150-lb. thrusters for orbit-keeping. NASA says these actuators will provide maneuver capability about all three axes and serve to "dump," or desaturate, the CMG's, providing a torque for the lab each time the applied impulse exceeds the gyro's storage capacity.

In addition to providing rate-limited optimum on/off fuel control in the zero-g mode, the RCS also is used extensively for spin control during the initial artificial-g operation and for precession control, using a masked sun sensor to generate control commands during the rotating mode.

• **Manual control possible**—To inject the full benefit of crew capability into *MORL* control, the station is also expected to include a separate all-attitude inertial reference package, coupled to a ball-indicator-type of display, to be used primarily during periods of extensive maneuvering during rendezvous operations or for certain experiments. The system will include three single-axis stable platforms and a digital computer. Use of separate platforms rather than a more conventional multiple-gimbal package was dictated mainly by ease of in-flight maintenance and single-unit replacement considerations.

Tests using a manually operated simulator at Langely reportedly have shown that man can operate in a control loop using momentum-storage systems and can actually hold some accuracies better than automatic systems at current levels of development.

According to the Phase IIa evaluations, the *MORL* SCS, using the basic horizon sensing and gyro-compassing arrangement for a baseline attitude reference, should be able to provide a basic attitude-hold accuracy of ±0.5 deg., a stabilization rate hold of 0.06 deg./sec., and a virtually unlimited maneuvering rate capability with the RCS.

While this is reported to satisfy all mission operational requirements—and most of the experimental requirements, further improvements must be made if the system is to satisfy all of the experiments envisioned.

Improvements are expected to come through addition of star trackers to raise the accuracy of the basic attitude reference, through isolation of extremely precise experiments (such as astronomical telescopes) from the laboratory by various gimbaling schemes, and possibly by some restrictions on crew motion.

The recommended improvement to the attitude reference capability involves addition of a pair of automatic star trackers to increase reference accuracy to better than 0.01 deg., and, allowing full crew freedom of motion, yield an attitude-hold capability of about 0.1 deg. This figure is reportedly sufficient to handle about 87% of the *MORL* experiments that need stabilization (about 91 experiments are being considered for *MORL*, 37 of which require some kind of stabilization).

By restricting crew motion and other internal mass movements during critical experiment operation, engineers say, the stabilization rate hold can be improved from 0.06 deg./sec. (sufficient for about 68% of the experiments) to 0.005 deg./sec., a rate satisfactory for nearly all of the experiments.

• **Critical experiments**—However, in order to avoid restricting crew motion, the Douglas-Bendix team has analyzed three of the most critical experiments, from the standpoint of pointing accuracy, which fall outside of the capabilities of merely an improved reference SCS.

These include:

—A photo-optical package for Earth-surface tracking demands that the absolute attitude error should be no worse than 0.1 deg./sec. The recommended solution is to gimbal the instrument relative to the lab structure, using the all-attitude sensor as the command reference and the star trackers for initial attitude-reference conditions.

—A 40-in. reflecting astronomical telescope, whose optical axis must point with high accuracy to selected stars for spectrometric analysis, will require an accuracy of 0.1 arc sec. for low-magnitude stars. Also, photographic recording requires that the scope's roll axis be stabilized. The solution here appears to lie in gimbaling of the entire telescope and providing an entirely self-contained stabilization system, something engineers here see as evolving out of the hardware being developed for the *Orbiting Astronomical Observatory (OAO)* program.

—A horizon spectrometry experiment, which points a camera-radiometer sensor towards the Earth, has a pointing accuracy design goal of 0.01 deg. The recommended approach here is to gimbal the sensor based on commands from the star tracker reference and the data-processing computer to compensate for laboratory motion.

In all three of these approaches, complete crew freedom would be permitted.

The NASA-industry *MORL* team has also made important analyses of the various *MORL* orientation modes. The ability to remain in favorable orientations for long periods, from the standpoint of economical system operation, will have a definite effect upon SCS demands.

For example, while the *MORL* must have the capability of holding orientation in any direction, mission analysis shows that about 70% of orbital time may be spent in any favorable orientation. For *MORL* in zero-g operation, this principal long-term orientation will be the so-called "Roll-Solar" mode, in which the Y-axis is controlled to remain in the orbit plane with the longitudinal axis pointed at the Sun. This orientation results in cyclic gravity-gradient torques, according to NASA, and allows use of fixed solar panels—a very important consideration since it means that solar panel gimbaling mechanisms will not have to be used for long periods.

While *MORL* designers are now planning on using large solar-cell arrays, they are not overjoyed at the prospect for several reasons. Among them are the necessity of gimbaling these for various orientations, the possibility of mechanical breakdown during rotation, and the impingement of RCS gases upon the panels. Planners are very much interested in both radioisotope or nuclear generator systems as a possible replacement and have sponsored some studies. Firms active in this area related to *MORL* include Garrett, Atomics International Div. of North American Aviation, Inc., and the Martin Co.

For about 24% of the time, NASA says, rendezvous, orbit keeping, and Earth-oriented experiments will require a so-called "Belly-Down" mode. In this mode, the Y-axis is aligned with the local vertical and the X-axis points along the orbital velocity vector. While external disturbances are minimal and control system weight and power expenditures are lowest, the solar arrays require continuous gimbaling, and extensive gas impingement occurs.

Artificial-g requirements are satisfied by a Solar-Oriented mode in which the lab's spin axis is pointed toward the Sun. Economy of operation is poor, but the solar panel rotation is eliminated. ■

Emulsions Win Growing Attention

Technology seen of potentially great value in raising energy levels; Petrolite Corp. is major center of knowledge

by John F. Judge

A NEW APPROACH—emulsions—is now being examined for the job of marrying high-energy solids to liquid-rocket engines.

At least one firm, Reaction Motors Division of Thiokol Chemical Corp., has experimented with emulsions in the past year. The major area of development at RMD, as at other large propulsion firms, is in gels—the suspension of a solid in a liquid.

Both industry and Air Force funds are being used in developing the broad field of such colloidal propellants, but the state of the art in gels is much more advanced than that of emulsions.

Every specific system has its own problems, RMD experts say, but the primary one is stability in the anticipated environment. This can be either the mechanical stability of the system or the reactivity among the components of a propellant system.

In addition, the gel or emulsion must have flow characteristics amenable to the pumping and injection modes prevalent in liquid rocket engines.

Detailed work in gels or other thixotropic systems is classified, but the effort has reached the level of firing tests in some systems, along with pilot-plant production and handling techniques.

● **Tretolite**—A top center of emulsion knowledge and technology in the United States is the Tretolite Division of the Petrolite Corp. The firm started 30 years ago by developing agents and techniques designed to break natural emulsions found in oil fields.

Dr. Kenneth J. Lissant, advanced research coordinator of Petrolite Corporate Research Labs., says literally thousands of new chemical identities have been developed in work on emulsions.

Tretolite has worked mostly in non-aqueous compositions and is one of the world's few sources of this technology. The classical limit to the external phase of any emulsion has been about 70 to 74%—but Lissant and his researchers have long since passed this mark in fairly stable emulsions. The ultimate limit now seems to be a monomolecular film between droplets.

● **Basics**—Emulsions belong to the general chemical area known as colloids. Lissant maintains that colloidal chemistry is the last and most lightly treated section of a standard four-year college chemistry course. Even the latest books are sadly out of date. Most of the technology is concentrated in the proprietary areas of a handful of firms and in the patent disclosures of these firms.

An emulsion is basically a continuous liquid phase containing a second, discontinuous, immiscible liquid phase. But Lissant says this falls far short of an adequate definition.

The most convenient way to classify emulsions is to divide them into two large groups—determined by the nature of the external phase. These are usually oil-in-water and water-in-oil emulsions—with the "oil" and "water" terms being extremely general.

Lissant's next step is to divide the

GLOSSARY OF RHEOLOGICAL TERMS

Prepared by the Interagency Working Group on Liquid Propellant Test Methods

A. Classification of fluids

Class I. Newtonian fluid

A Newtonian fluid is one that exhibits a direct proportionality between shear stress and shear rate in the region of laminar flow. The shear rate is independent of the time of application of shear stress.

Class II. Non-Newtonian shear-thinning fluid

A non-Newtonian shear-thinning fluid is one in which the shear stress is not directly proportional to the shear rate and in which the shear stress-shear rate ratio decreases as the shear stress increases.

Type a. Plastic fluid

A plastic fluid is a Class II fluid that exhibits a change in shear rate directly proportional to the change in shear stress above the yield stress.

Type b. Pseudoplastic fluid

A pseudoplastic fluid is a Class II fluid that exhibits a shear stress-shear rate ratio that is independent of the duration of application of shear stress.

Type c. Thixotropic fluid

A thixotropic fluid is a Class II fluid that exhibits time-dependent, reversible changes of the shear stress-shear rate ratio. The ratio decreases asymptotically with duration of shear.

Class III. Non-Newtonian shear-thickening fluid

A non-Newtonian shear-thickening fluid is one in which the shear stress is not directly proportional to the shear rates, and in which the shear stress-shear rate ratio increases as the shear stress increases.

Type a. Dilatant fluid

A dilatant fluid is a Class III fluid that exhibits a shear stress-shear rate ratio that is independent of the duration of application of shear stress.

Type b. Rheopectic fluid

A rheopectic fluid is a Class III fluid that exhibits time-dependent, reversible changes of the shear stress-shear rate ratio. The ratio increases asymptotically with duration of shear.

B. List of definitions

1. Yield stress

The yield stress is the maximum shear stress that can be applied without causing permanent deformation.

2. Viscosity

The viscosity is the ratio of shear stress to shear rate. For non-Newtonian fluids, it is preferable to report shear stress and shear rate. If the viscosity of such a fluid is reported, the shear rate must be specified.

mulsions into three classes, based on he volume percentage of the internal hase. These he categorizes as less-than-0% internal phase, 20-to-about-70% nternal phase and those emulsions with nore than 70% internal phase.

The volume percentage of the internal phase has a definitive influence on he properties of the emulsion. For example, if a small amount of liquid is dded to a container partially filled with nother, immiscible, liquid, it will coaesce and form a layer with an interface etween the two liquids.

When a material is added to prevent he coalescence of the second liquid, it reaks up into droplets as it is poured nto the container and forms a loose mulsion. Lissant says each of these roplets is essentially spherical, and the ystem can be idealized as a collection f spheres suspended in a liquid.

- **"Creaming"**—Unless these individual droplets are small enough to be ept in suspension by thermal forces, hey will eventually settle out or rise o the top, forming a layer of droplets. This is termed "creaming."

When the internal phase is less than 20% of the volume, the physical properties of the whole system are primarily determined by the nature of the external, continuous phase.

As the internal phase percentage is increased, the droplets collide more frequently, causing an apparent increase in viscosity of the whole system. As the internal phase nears 74% by volume, the whole system begins to look like the creamed phase.

If the system contains more than 74% internal phase, the droplets are so closely crowded that their spherical shape is affected. At this point, says Lissant, the apparent viscosity of the system increases rapidly and non-Newtonian behavior becomes marked.

As long as the emulsifiers prevent coalescence in these high-internal-phase systems, the emulsion is stable. It is these systems that have been used for propellant application.

- **Influence of geometry**—Lissant contends that many of the properties of these emulsions arise purely from the geometry of the system. If uniform spheres are packed as closely as possible, the spheres will occupy a little more than 74% of the total volume.

Even if the spheres differ in size, the packing will be somewhat different but the principle remains the same, says Lissant. Experimental evidence suggest that actual emulsion particles tend to b uniform in size.

In the close-packed condition, says Lissant, each sphere touches 12 other spheres. As the internal phase ratio exceeds 74%, each droplet should be flattened at the point of contact. The flattening becomes more pronounced as the phase ratio increases—until each droplet becomes polyhedral. The result is a collection of polyhedra separated by a thin, continuous film of the external phase.

Lissant and his researchers have studied the shapes these droplets may be expected to assume and experiments have shown that the actual droplets do

3. Apparent viscosity

The apparent viscosity of a non-Newtonian fluid is the viscosity of a Newtonian fluid that produces the same reading in the same apparatus under identical conditions. Avoidance of this artificial term is recommended.

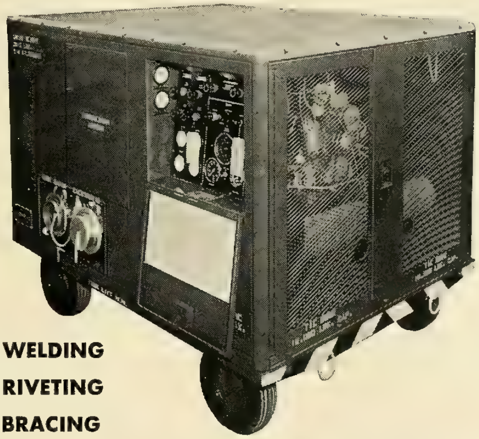
4. Gel

A gel is a liquid containing a colloidal structural network that forms a continuous matrix and completely encloses the liquid phase. A gel deforms elastically upon application of shear forces less than the yield stress. At shear forces above the yield stress, the flow properties are principally determined by the gel matrix.

5. Emulsion

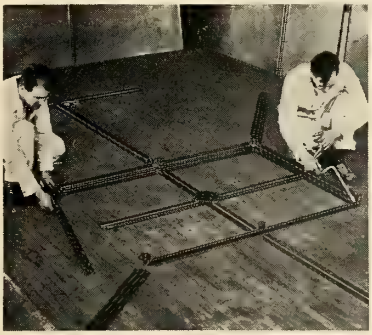
An emulsion is a two-phase liquid system in which small droplets of one liquid (the internal phase) are immiscible in, and are dispersed uniformly throughout, a second, continuous liquid phase (the external phase).

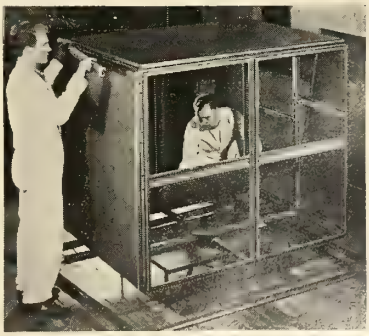
Enclose Anything
(INCLUDING GROUND SUPPORT EQUIPMENT)
with Lindsay Structure!



NO WELDING
NO RIVETING
NO BRACING

Utilizes the tremendous strength of sheet metal under uniform tension.
ASSEMBLES WITH SCREWDRIVER





WRITE FOR FREE FOLDER
LINDSAY STRUCTURE
DIVISION OF INTERNATIONAL STEEL COMPANY
1543 Edgar St. • Evansville, Indiana 47707
Circle No. 7 on Subscriber Service Card

form shapes in close agreement with those predicted from pure geometry.

There are strong indications that small elastic spheres in close-to-maximum packing situations show much the same flow properties seen in emulsions.

- **Emulsifier critical**—The key to an emulsion lies in the selection of the emulsifying agent or agents and the method of preparation. Both technologies are proprietary with Tretolite and are founded on decades of breaking emulsions for the oil industry.

Investigations at Tretolite have shown that the apparent viscosity of an emulsion can be varied by selection of the emulsifier and by the method of preparation. Other properties, such as heat stability, can be controlled through proper emulsifier selection.

Low- or moderate-internal-phase-ratio emulsions require the production of small-size droplets if creaming is to be avoided. But all propellant emulsions envisioned at this time are high-internal-phase-ratio emulsions, in which there is essentially no room for the droplets to settle. The controlling factor is then the prevention of coalescence.

Since small droplet size is not required for stability in high-internal-phase emulsions, the preparation does not require the high-shear equipment used for other emulsions.

Lissant and his staff can easily prepare small hand batches of specified fuel emulsions in ordinary beakers using laboratory stirrers. Small pilot-plant batches have been made with recirculating pump systems and with much the same equipment used in gel preparation.

The essential part of the process is to be sure that the emulsion gets started with the fuel as the internal phase, says Lissant.

Lissant has considered full-scale continuous production methods.

- **Suspending solids**—The general rule for suspending a solid in an emulsion is that the external phase should not wet the solid particles. The solids should be preferentially wetted by the internal phase. If these conditions exist, the solid will work itself into the emulsion in a stable manner.

The external phase film between droplets will hold the solid particles in suspension—and this suspension will be as stable as the emulsion itself.

This approach is a specific of the general rule that all components of an emulsion must be compatible. It is also possible, says Lissant, to use a slurry as the internal phase of an emulsion.

Lissant has kept stable emulsion samples with 43% by weight of aluminum loading for more than 300 days in the laboratory. Other efforts of the firm include emulsions based on hydrazine in kerosene, and emulsions of a suspension of aluminum in hydrazine in kerosene. ■

Boeing Steps Up Efforts In Cryogenics Research

by Robert Twiss

THE BOEING CO. for the first time since 1920 doesn't have a fixed-wing military airplane in production at any of its sprawling aerospace plants. But the Seattle firm, now bidding on additional military aircraft programs such as the C-5A recently approved by President Johnson, long ago embarked on a widespread diversification program.

Boeing is working energetically in areas such as advanced ballistic missiles, ICBM counters, improved gas-turbine engines, satellite inspectors and interceptors, and propulsion. Its work in advanced rocket propulsion, with the exception of its important assignment to develop and produce the S-1C first-stage booster for the *Saturn V* launch vehicle, has been little publicized in recent years.

Boeing's work ranges from studying methods that might yield more energy to the S-1C, through use of exotic fuels such as Flox, to advanced spaceborne propulsion systems that might eventually succeed the highly successful Lockheed *Agena* upper stage.

Rocket-propulsion studies, involving systems using various cryogenic fuels, were stepped up beginning about three years ago. Today, the firm has about 200 of its top Aerospace Division technical personnel working on a number of research and development programs aimed at improved rocketry through use of exotic fuels.

Specifically, in the past three years, Boeing has:

—Invested more than $2.2 million of its own funds to build rocket test facilities at Boardman, Ore. The test stand and supporting facilities, including full instrumentation and a blockhouse, are being readied for testing now.

—Stepped up its research and development work in cryogenic fuels and materials to withstand the supercold temperatures of these propellants in its Seattle-area facilities.

—Substantially increased investment and test work at its nearby Tulalip Test Site, which is about 30 miles north of Seattle on land leased from a Western Washington Indian tribe.

—Constructed, installed and begun testing on what the company believes to be the largest flightweight cryogenic tank ever built for long-term storage of exotic fuels in space. This work is under way now at the Tulalip Test Site.

- **Tipoff**—The first indication of Boeing's growing interest in cryogenic propulsion came last April, when George H. Stoner, Boeing vice president and head of the launch systems branch of the Aerospace Division, revealed that the company was undertaking in Seattle "a thorough exploration" of the application of cryogenic propellants to space propulsion. Stoner said then he saw a definite need for "a good, high-energy upper stage for maneuvering and acceleration in space."

Stoner said Boeing's new Boardman test site, which covers 100,000 acres in Northeastern Oregon adjoining the Columbia River, is "ideal" for testing high-energy stages. He said that Boeing would propose development of such a system to both NASA and the Air Force.

Stoner was quick to point out there are "many knotty technical problems" in developing such a system, but he said successful development of a high-energy stage could lead to "tremendous payoffs" for both NASA and military programs.

Boeing is bidding on both Air Force and NASA studies and hardware in the cryogenic field, including secret Air Force work that the company declines to discuss. Its work in the field of cryogenics is being directed by Stoner and by John F. Milton, development program manager for advanced launch and propulsion systems.

- **Genesis**—Boeing's interest in cryogenics began on a modest scale about three years ago. The company's facilities officials began searching for a remote test site in the Pacific Northwest reasonably close to its main Seattle-area operations. The search finally centered on the Boardman area.

Now, with construction completed, Boeing is busily preparing its rocket test stand at Boardman for test runs of a Pratt & Whitney RL-10 liquid hydrogen-oxygen engine. The engine was obtained rom NASA, and the entire system is xpected to be ready for testing by pring.

The RL-10 will be the first of many ngines that Boeing plans to test at oardman; other more modern engines ill be evaluated there as they become vailable. Boeing is working with all ocket-engine manufacturers so that it an analyze each engine application to uture propulsion systems. It will use the RL-10 to analyze the dynamics of a ryogenic propulsion system.

The Boardman test stand can acommodate rockets with thrust of up to 00,000 lbs., which indicates the energy ange that Boeing is interested in at the oment. However, if the company is uccessful in winning contracts in propulsion systems in this range, it appears nly logical that the Boardman test failities will be expanded to include enines of far greater thrust.

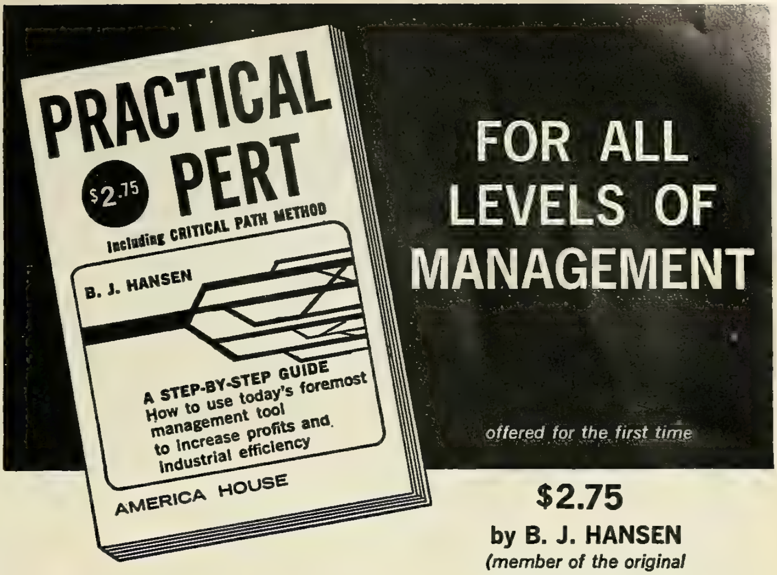
One feature of the Boardman facility is a 90-gallon-capacity flow facility, which Boeing will use to study virtually ll of the exotic propellants being conidered for future use.

- **Education**—Work at Tulalip also overs a wide range of propulsion subjects. The company has developed a mall flow facility there with a ten-galon capacity. This unit has been in operation for nine months and has yielded ignificant information about such cryogenic fuels as fluorine, for example. Early lessons learned included the need or absolute cleanliness in dealing with his hypergolic liquid and the fact that many standard, off-the-shelf items simply aren't adapted for use with supercold fuels. Valves, for example, which upposedly were capable of accommodating fluorine, were found to have a cleaning and sealing problem. Boeing promptly changed from polymer type eals to fluorine-derivative compounds.

In early testing with its cryogenic lightweight tank, Boeing found that the ank design was appropriate but that heat leaks developed in the supporting nstrumentation. Rework was required o solve this problem. Boeing already has tested its cryogenic tank in the vacuum chamber built at Tulalip for the canceled *Dyna-Soar* program. The tests checked out reaction of cryogenic fuel o "hazardous" altitudes with satisfacory results.

Boeing engineers think cryogenic anks can be developed to sustain exotic uels in space up to a year.

- **Upgrading Saturn**—Boeing Flox studies aren't confined to space propulsion systems. Engineers are working vigorously on use of Flox, for example, with the S-1C. They are confident this high-energy fuel, with modest changes n S-1C engine and tankage, could result in a substantial payload increase for the huge *Saturn V* launch vehicle. ■


PRACTICAL PERT
$2.75
Including CRITICAL PATH METHOD
B. J. HANSEN
A STEP-BY-STEP GUIDE
How to use today's foremost management tool to increase profits and industrial efficiency
AMERICA HOUSE
FOR ALL LEVELS OF MANAGEMENT
offered for the first time

$2.75

by B. J. HANSEN
(member of the original Polaris-PERT Team)

You get the complete PERT system and, for the first time, a PERT technique showing you how to predict and monitor profit on a continuing bi-weekly cycle.

Chapter XI, "Profit PERT and Incentives," brings you the Martin Company case history showing how the Titan III PERT-profit system works: In the words of Secretary of Defense Robert McNamara, "(Titan III) is probably the best managed contract we have, and it is the best managed almost entirely because of the tremendous incentive given to that contractor in the form of potential profit increases to hold his costs down."

PRACTICAL PERT tells how and when to meet contract obligations, how to keep programs on schedule, how to win highest incentive fees. PERT, developed for the nation's defense programs, can be applied to management operations to monitor profit as well as cost, time and performance in the fields of construction, chemical processing, manufacturing . . . and wherever complex systems are involved.

PRACTICAL PERT contents

I INTRODUCTION TO PERT
II THE ABC'S OF PERT
III PERT & TIME
IV HOW PERT PLANS
V HOW PERT CONTROLS
VI BUILDING PERT
VII WHAT IS NETWORKING
VIII REFINING THE NETWORK
IX MEASURING MANAGEMENT RISK
X PERT & COST
XI PERT COSTS & COMPUTERS
XII PROFIT PERT & INCENTIVES
XIII PERT DATA DISPLAY

AMERICA HOUSE
1001 Vermont Avenue, N.W., Washington, D.C. 20005

Send Me ☐ Copies of Practical Pert $2.75 / .25c Handling / $3.00

☐ Check Enclosed ☐ Bill Me

Name________________ Job/Title________________

Address________________ City________________

Zip Code__________ State__________ Co. Name________________

UNITED STATES

Launch Systems opportunities at Boeing

Boeing's Launch Systems Branch, a major contractor on NASA's Saturn V program, has a number of exceptional openings for qualified engineers and scientists. These assignments offer you the unique growth advantages of a rapidly expanding, long-range program, and the professional prestige of association with one of the world's major space efforts.

Openings are available in New Orleans, La., Huntsville, Ala. and Cape Kennedy, Fla. for specialists in the following areas: systems engineering, simulation systems, ground systems, flight technology, electronics technology, electronic/electromechanical parts development, hydraulics, structures, instrumentation, dynamic stability, production testing, aerospace program planning, spares maintenance, electrical materials and processes, scientific computer programming, and operations management.

Salaries are commensurate with all levels of education and experience. All openings require a B.S. or advanced degree in engineering or physics, and applicable work experience. Boeing pays travel and moving allowances to newly hired personnel. Boeing is an equal opportunity employer.

Advance your career with the Saturn V program at Boeing. Take a moment now to send your resume to Mr. L. Wendell Hays, The Boeing Company, P. O. Box 29100-MSV, New Orleans, Louisiana 70129, Mr. John Hall, The Boeing Company, P. O. Box 1680-MSV, Huntsville, Alabama, or to Mr. L. S. Bonsteel, Boeing Atlantic Test Center, P. O. Box 1698-MSV, Cocoa Beach, Florida.

BOEING
AERO-SPACE DIVISION

Mergers and Acquisitions

General Dynamics Corp. has consolidated its Stromberg-Carlson Div. with the United States Instrument Corp. The company thus established will be known as the Stromberg-Carlson Corp. GD will retain 88½% of the common stock of the new company. Payson & Trask, a New York investment firm that held much of the U.S. Instrument stock, is to retain its interest in the surviving firm. Stromberg-Carlson specializes in the manufacture of telephones. U.S. Instruments makes a wide range of complementary communications equipment. . . . *Varian Associates, Palo Alto, Calif., has agreed to acquire LEL, Inc., a microwave electronics company located in Capicague, N.Y., and its wholly owned subsidiary, Micro-Link Corp. The plan is to be submitted for stockholder approval this month. The negotiation comes immediately after Varian purchased Mikros, Inc., a Portland, Ore., firm specializing in electron microscopes and vacuum equipment (Jan. 4, p. 41).* . . . Hi-Spec Electronics Corp., Van Nuys, Calif., relay manufacturer has been purchased by Del Quigley of San Jose and John Mattson of Interstate Engineering Corp., Anaheim, Calif. Hi-Spec will continue developing and producing micro-miniature and sensitive electromechanical devices designed for military and space applications.

New Activities

Honeywell, Inc., has formed a Systems & Research Div. in Minneapolis to strengthen its capability to create and conduct major military and space programs. The consolidation will bring into one location systems operations presently under way in several divisions. The new division will consist of departments including the former military products group research laboratories, the space and armament systems department of the aeronautical division in Minneapolis, the systems engineering departments of the ordnance division and the Florida aeronautical division. . . . *Components Corp., Pasadena, Calif., has opened its third division with offices in San Diego. The office will provide engineering and sales representation for manufacturers of equipment for the aerospace and related industries in San Diego and Imperial counties.* . . . Planalog, Inc., of Philadelphia has established a Western regional office in Los Angeles to provide consulting services in the aerospace, computer, metals, petroleum, shipbuilding and other industries.

ARC Acts to Improve Financial Stance

Atlantic Research Corp. has taken action on several fronts in an effort to shore up its sagging financial situation. The Alexandria, Va., firm has been under pressure from the SEC since 1962, when the commission charged ARC with misrepresenting its financial situation by failing to list all of its holdings. ARC has now announced its acquisition of all outstanding stock of Texas Capital Investment, Inc., a firm to which ARC loaned funds several years ago while at the same time leasing facilities from it. The SEC claimed that as a result TCI should have been listed at that time on ARC's financial statements as a subsidiary. In December, 1963, the SEC issued a "stop order," which halted registration and public sale of 179,000 outstanding ARC common shares. The firm hopes that clarification of the ARC-TCI relationship will improve its position with the SEC. Ancillary to the acquisition is the proposed settlement of a suit against two of the firm's officers filed on behalf of the company by Samuel Meltzer, a New York stockholder. Meltzer alleged that officers and directors of ARC in office during the original agreement with TCI had allowed improper expenditures of corporate funds to make such loans. The proposed settlement, due for a hearing before a Federal district judge in Richmond Feb. 12, calls for former president Arch C. Scurlock and A. W. Sloan, who was executive vice president at the time, to pay the firm $500,000 each over the next five years. The settlement was agreed to "without admission of any fact alleged in the complaints," on the part of the officers and directors charged. The company said it was agreed to because of "the desirability of settling and terminating the actions and claims to avoid the expense, burden and consumption of time which would result from further protracted litigation." ARC, in still other financial actions, has announced its purchase of a 2,000-acre rocket motor test site it has been leasing in North Carolina and its acquisition of a new $8-million line of credit from two banks.

Missile/Space Facilities

Aero-Space Avionics has moved from Farmingdale, N.Y., to a new custom-built facility at Bohemia, N.Y. The plant contains 8,000 sq. ft. of air conditioned work space, and has a moveable wall allowing ready expansion to 16,000 sq. ft. Aero-Space manufactures and markets special support equipment, power supplies and related aerospace electronic test gear for airframe and aerospace companies. . . . *Bell Aerosystems Co. has begun construction of a 4000-sq.-ft. clean room in Buffalo, N.Y. The new facility will be used for fabricating positive expulsion tanks and for assembly of rocket engines for Project Apollo. Design of the room provides for a complete change of air every minute and the filtration of all dirt particles 0.3 microns and larger.* . . . Hewlett-Packard Co., Palo Alto, Calif., has awarded a $2,168,000 contract for the construction of an approximately 175,000-sq.-ft. expansion of its Stanford Industrial Park headquarters. Included in the plans are a 125,000-sq.-ft. building and a 50,000-sq.-ft. underground warehouse. . . . *Texas Instruments, Inc., has established a facility at Ridgecrest, Calif., adjacent to the Naval Ordnance Test Station there. The 3,300-sq.-ft. building will be used for systems design work on advanced weapons, for engineering support on current programs, and for field test monitoring of Shrike missile production.*

contracts

AIR FORCE

$13,780,000—**Rand Corp.**, Santa Monica, Calif., for aerospace research services.

$8,200,000—**Mitre Corp.**, Bedford, Mass., for continued R&D on command and control systems.

$4,619,999—**Fairchild Hiller Corp.**, Bay Shore, N.Y., for electronic equipment for use with aerial cameras.

$2,075,000—**Garrett Corp.**, Phoenix, Ariz., to continue work on development of a space power unit.

$1,472,500—**Dynamic Corp. of America**, Long Island City, N.Y., for production of communications equipment.

$1,300,000—**Hughes Aircraft Co.**, Culver City, Calif., letter contract for integration of *AIM-4D* missile with F-4 aircraft.

$1,274,758—**Washington Aluminum Co.**, Baltimore, for container sets for *Bullpup* air-to-ground missiles.

$1,117,900—**Space Sciences, Inc.**, Waltham, Mass., to produce recording equipment.

$1,056,700—**Electro-Optical Systems, Inc.**, Pasadena, Calif., for production of orbital flight systems.

$1,034,773—**Ralph M. Parsons Co.**, Los Angeles, for services at various *Titan II* bases.

$595,000—**Sperry Rand Corp.**, Salt Lake City, Utah, for production of TDU-9/B tow target.

$170,514—**Avco-Everett Research Lab.**, Everett, Mass., for research on properties of collisionless plasmas.

$107,242—**American Bosch Arma Corp.**, Arma Div., Garden City, N.Y., for service engineering in support of *Atlas E* and *F* guidance systems.

ARMY

$4,385,110—**Bell Aerospace Corp.**, Buffalo, for airborne target locater systems.

$2,508,377—**Dynalectron Corp.**, Washington, for services performed in installation, operation and maintenance of government-owned data-collecting facilities at White Sands Missile Range, N.M.

$2,326,566—**FMC Corp.**, Newport, Ind., for work at the Newport chemical plant.

$2,130,000—**Technical Operations, Inc.**, Burlington, Mass., for continuation of research and scientific combat development studies.

$1,379,188—**Western Electric Co.**, Burlington, N.C., for modification kits for *Hercules* surface-to-air missiles.

$1,199,873—**Telecomputing Services, Inc.**, Panorama City, Calif., for preparation of data-reduction reports on missiles and test vehicles.

$1,165,373—**Raytheon Co.**, Lexington, Mass., for work on *Hawk* missiles.

$1,126,607—**Dynalectron Corp.**, Washington, for data processing of Navy test of missile components.

$350,000—**General Dynamics Corp.**, Pomona, Calif., for FY 1965 *Redeye* program.

NAVY

$18,715,692—**Goodyear Tire & Rubber Co.**, Akron, Ohio, for production of *SUBROC* ASW missiles.

$14,868,207—**General Electric Co.**, Schenectady, N.Y., to design and manufacture nuclear reactor components.

$13,050,000—**General Dynamics Corp.**, Pomona Div., Pomona, Calif., for fiscal 1965 funding for development and pilot production of a medium range standardized version of the *Tartar-Terrier* type surface-to-air missile.

$6,000,000—**Westinghouse Electric Corp.**, Pittsburgh, for design of a missile guidance system.

$4,341,000—**Sperry Rand Corp.**, Syosset, N.Y., for engineering work on inertial navigation systems for use aboard U.S. and British ballistic submarines.

$3,498,155—**Sperry Rand Corp.**, Charlottesville, Va., for work on target-control systems for the ASW helicopter program.

$3,337,962—**Raytheon Co.**, Waltham, Mass., for manufacture of *Polaris Mark II* electronic guidance assemblies.

$2,936,200—**Sperry Rand Corp.**, Great Neck, N.Y., for production of navigation systems for installation aboard *Apollo* tracking ships.

$2,645,000—**Westinghouse Electric Corp.**, Pittsburgh, for research and development of nuclear propulsion plants for naval vessels.

$2,403,571—**Goodyear Aerospace Corp.**, Litchfield Park, Ariz., for spare parts for radar equipment.

$2,253,300—**Westinghouse Electric Corp.**, Pittsburgh, for production of a *Polaris* missile launcher system for Great Britain.

$2,073,358—**Bendix Corp.**, Teterboro, N.J., for programmer systems for aircraft.

$1,498,000—**Westinghouse Electric Corp.**, Pittsburgh, for converting a submarine to an up-to-date *Polaris* missile-launcher system.

$1,316,790—**Hughes Aircraft Co.**, Culver City, Calif., to design, develop, fabricate and furnish experimental, portable, self-contained, deck-mountable, shipboard satellite communications sets to facilitate ship-to-ship and ship-to-shore communications via *Syncom II* and *III*.

$1,210,000—**Maxson Electronics Corp.**, Great River, N.Y., for additional AQM-37A missile targets.

$482,707—**General Electric Co.**, Pittsfield, Mass., to manufacture and test one *Polaris* MK 84 digital computer modified for MK 113 training use.

$382,580—**North American Aviation, Inc.**, Rocketdyne Div., McGregor, Tex., for *Sidewinder IC* rocket motors, MK36.

$245,847—**Radio Corp. of America**, Communications Systems Div., Camden, N.J., for an additional contract on the AN/ARC-38A program.

NASA

$196,500—**Electro-Optical Systems, Inc.**, Pasadena, Calif., for feasibility studies of promising stability and gravity (including zero-G) experiments for manned orbiting missions.

$155,006—**Avco-Everett Corp.**, Research Lab., Everett, Mass., for study of plasma radiation shielding.

$140,443—**Giannini Controls Corp.**, Duarte, Calif., for the first system designed to measure and record data from launch vehicle test firings in digital, as opposed to analog, form.

$80,000—**Raytheon Co.**, Lexington, Mass., to explore atmospheric phenomena met by radio signals sent at millimeter wave frequencies.

$44,287—**Canadian Commercial Corp.**, Ottawa, Canada, for study for stem-type booms for applications technology satellite program.

The Bendix Corp., South Bend, Ind., for the study of the touchdown dynamics of the *Lunar Landing Research Vehicle* (amount undisclosed).

Emerson Electric Co., Electronics & Space Div., St. Louis, for preliminary design and testing of a heat shield system for the *Apollo* three-man spacecraft to protect the vehicle during ascent and re-entry from manned orbital and lunar flights (amount undisclosed).

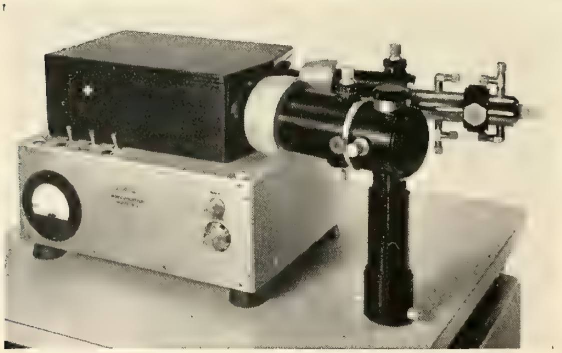
INDUSTRY

$6,200,000—**Fairchild Hiller Corp.**, Electronic Systems Div., Washington, from McDonnell Aviation, St. Louis, for production of additional auxiliary data annotation sets aboard McDonnell's RF-4 advanced reconnaissance aircraft.

$1,330,040—**Chicago Bridge & Iron Co.**, Pasadena, Calif., from Catalytic Construction Co., Mercury, Nev., for two 500,000-gal. liquid hydrogen storage vessels and one 250,000 water storage tank, to be installed at Test Cell "C," Nuclear Rocket Development Station, Nev.

$1,200,000—**Brunswick Corp.**, Lincoln, Neb., from Hercules Powder Co., Wilmington, Del., for glass fiber cases for second-stage motors for *Polaris* missiles.

$664,000—**P.M.I. Corp. of Concord**, Concord, Calif., from Catalytic Construction Co., Mercury, Nev., for modifications to Test Cell "C," at the Nuclear Rocket Development Station.



A NEW INSTRUMENT
FOR THE FAR ULTRAVIOLET

TROPEL MODEL N-2 MONOCHROMATOR
equipped with
Model BNH-1 Discharge Tube & Model S-2 Reflectometer

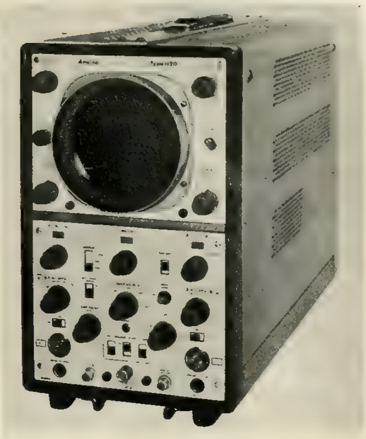
The Model N-2 Monochromator is an improved normal incidence grating instrument which produces exceptionally intense and pure spectra. The N-2 design features a compact vacuum chamber (total volume, 0.25 cu.ft.), and a high speed four inch diffusion pump, a six speed motor driven wavelength scanning system, and manually controlled scanning. The newest addition to the Model N-2 line of accessories is Tropel's Differential Pumping Chamber, a unique device which enables operation of the Monochromator with a windowless light source, at pressures as low as 8 x 10⁻⁶ Torr. Basic instrument—$6950.00

• *Write for brochures describing the new Model N-2 Monochromator and accessories*

TROPEL, INC. • 52 WEST AVE. • FAIRPORT, N. Y.
CONSULTANTS & DESIGNERS OF OPTICAL SYSTEMS
MANUFACTURERS OF PROTOTYPE LENSES & INSTRUMENTS

Circle No 8 on Subscriber Service Card

ew Product of the Week:
Sampling Oscilloscope



A sampling oscilloscope, said to be e first capable of displaying signals ith repetition rates as low as 1 pulse er second, has been announced by nalab Div. of Benrus Watch Co., Inc. ntil now, the firm said, sampling sys- ems have been able to operate only ith input signals above approximately 0 pps.

The Model 701-M1 features an elec- rometer memory circuit that makes it ossible to hold the memory sample for t least one second. Studies of high-frequency repeating laser and maser signals, occurring at low repetition rates, are now possible, company spokesmen say.

The device provides two display channels with a nominal risetime of 0.35 nanosecond and sweep ranges from 10 picoseconds to 2 microseconds per centimeter. The scope will internally trigger on sine waves or pulses with repetition rates from 1 cps to 1,000 megacycles, without the use of external countdown generators.

Circle No. 151 on Subscriber Service Card

olid-State Relay

The Model SSR-1285-5050 solid- tate relay, available from Solid State lectronics Co., is a silicon transistor- zed static switching relay with no mov- ng parts. The unit is an inertialess de- ice capable of over one trillion opera- ions. Actuation time is 2μs and drop- ut time is 5μs. Actuation frequency can e as high as 50 gc.

Epoxy encapsulation of the units is aid to make them immune to effects f shock and vibration.

Circle No. 152 on Subscriber Service Card

F Preamplifiers

IF preamplifiers Model 4573 at 60 nc and Model 4623 at 30 mc, both of vhich use all-silicon circuitry, are avail- ble from RS Electronics Corp.

The devices have a gain of 35 db and naximum noise figure of 4 db over the ange of —20° to 65°C. Available ver- ions offer bandwidth from 0.5 to 10 nc, with phase-matched pairs also avail- ble. Operation is linear from noise to —35 dbm with respect to input; pass- band ripple is 0.5 db or less. Adjustment llows gain setting down to 20 db.

Circle No. 153 on Subscriber Service Card

ifferential Amplifier

A solid-state amplifier with a band- vidth of dc to 400 cps is being marketed y Astrodata, Inc.

The Model 881-100 is designed for se in multi-channel, low-level data gathering systems. It has two output tages, ±5v at 10 ma and ±5v at 100 na. Output impedances are less than 1 hm and both outputs may be used imultaneously. Gain ranges are 10, 30, 100, 300 and 1,000, continuously vari- ble between steps.

The differential input circuit is floating and guarded, said to make it particularly useful in low-level transducer applications where high common mode rejection, high input impedance and low noise and drift are essential. Common mode rejection of 160 db at dc and 120 db at 60 cps is achieved with up to 1,000 ohms source resistance unbalance in either input lead. Common mode voltages may be as great as ±300v dc or peak ac.

Circle No. 154 on Subscriber Service Card

Character Generator

The Model 208 character generator, available from Datapulse, Inc., is designed to provide flexible control of data format and content for simulation of high-speed, multi-channel digital data.

The unit features 5-cps to 5-mc clock rate, 8-bit parallel characters, 1 to 16 serial characters per data block plus character or block repeats, 6-v output into 50 ohms and RZ or NRZ formats.

America's vital space centers...

just a
DELTA
JET
apart!
SAN FRANCISCO
KANSAS
LAS VEGAS
LOS ANGELES
SAN DIEGO
FT WO
HO
DELTA / PAN AM
THRU JETS TO AND FROM LONDON AND PARIS
NEW YORK
NEWARK
CHICAGO
DETROIT
PHILADELPHIA
WASHINGTON
CITY
CINCINNATI
MEMPHIS
ATLANTA
LLAS
TH
STON
NEW ORLEANS
TAMPA
ORLANDO
MIAMI
SAN JUAN
JAMAICA
CARACAS

- The only Jets between California and Atlanta-Orlando/Cape Kennedy
- 15 Jet flights daily between Dallas and California
- No lower Southern Airways – to – Jet fares between Huntsville and California than on Delta
- Deluxe and tourist on every flight

Call Delta or see your Travel Agent

DELTA®

the air line with the BIG JETS

In parallel mode, parallel characters with variable block length and control of blocks-per-frame permit simulation of paper or magnetic tape. Digitally controlled repeat is available for generation of longer effective patterns.

In serial mode, eight different 16-bit serial words may be commutated on a single line with digital control of words-per-frame for simulation of PCM data or multiplexing systems. Readout lights provide continuous indication of program status. Fifty-ohm output buffers drive interconnecting cables directly with no need for additional buffering.

Circle No. 155 on Subscriber Service Card

Linear/Log Recorder

A 10-in. potentiometric, null-balance linear/log recorder has been introduced by Dynatronic Instruments Corp. The servo-type instrument, called the Graphicorder-10, offers both continuous linear or logarithmic recording in one instrument.

The recorder has ±0.25% of span accuracy on all ranges and fast response of ⅔ second full 10-in. scale. Dual chart speeds are standard—1 in. per minute and 16 in. per hour. Six-speed chart drive is optional. The smallest significant changes in dc voltages can be plotted—from 300 mv to 10v.

Circle No. 156 on Subscriber Service Card

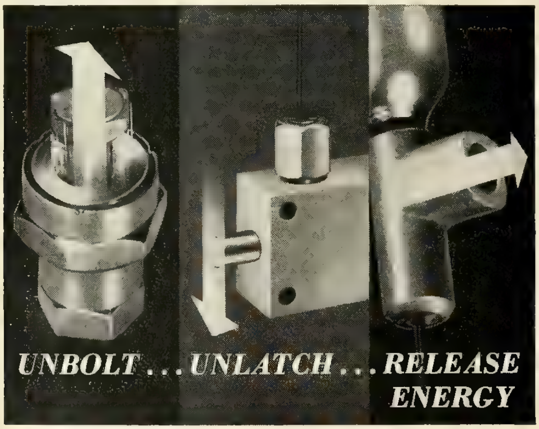
DC Voltage Standard

Production of the Model 323 portable dc voltage standard with output voltages from 0 to over 1,110v and accuracy within 0.01% has been announced by Cohu Electronics, Inc.

The stability of 0.0025% for eight hours or 0.005% for 30 days results from the use of a high-gain amplifier, stable feedback components and a temperature-controlled internal voltage reference. Six 11-position dials set output voltages in steps as small as 10 mv.

COHU
DC VOLTAGE STANDARD
MODEL 323

Circle No. 157 on Subscriber Service Card



in an instant . . . get

conax

EXPLOSIVE ACTUATED RELIABILITY

It's a fact . . . whatever can be done with explosive actuation, Conax does it more reliably . . . and their problem-solving ingenuity matches the dynamics of their technology, too! Since inventing the first explosive actuated valve for aerospace applications over twelve years ago, Conax has provided the widest range of the most reliable explosive actuated devices in the world . . . 99.99+% reliable, we mean! Get the facts in the free catalog B-1864.

CONAX EXPLOSIVE PRODUCTS DIV.
2300 Walden Avenue, Buffalo, N. Y. 14225 / 716-684-4500

Circle No. 9 on Subscriber Service Card

Input/Output Keyboards

A line of keyboards designed for electrical connection to card punches printer-punches, computers and other electronic input/output devices has been announced by Industrial Products Div of IBM Corp.

Several models, designed for specialized functions, are available. They include the Numeric Keyboard PE 707 the Alpha-Numeric Keyboard PE 708 and the Coded Output Keyboard PE 709.

The PE 707 contains 20 keys—10 numeric and 10 function or control keys. The PE 708 has 45 keys. Eighteen keys operate only when the keyboard is in alphabetic shift, 15 keys in either alphabetic or numeric shift and 12 are function keys. The PE 709 contains 53 keys, including seven function keys for space, backspace, line feed, carrier return and line feed, tab, shift and shift lock.

Circle No. 158 on Subscriber Service Card

Power Supply

A 25-kv, 4-amp dc power supply using solid-state components, is available from Energy Systems, Inc.

The Model 51-036 features a dry-type rectifier transformer and silicon rectifiers arranged in a 3-phase, full-wave bridge configuration. Complete controls, meters and status lamps are provided. Continuously variable motor-driven 0 to 25-kv voltage control is provided.

Protective features of the device include use of circuit breakers throughout; contractors, adjustable meter relay protection of overvoltage and overcurrent; transient protection of components and interlocks with status lamps.

Circle No. 159 on Subscriber Service Card

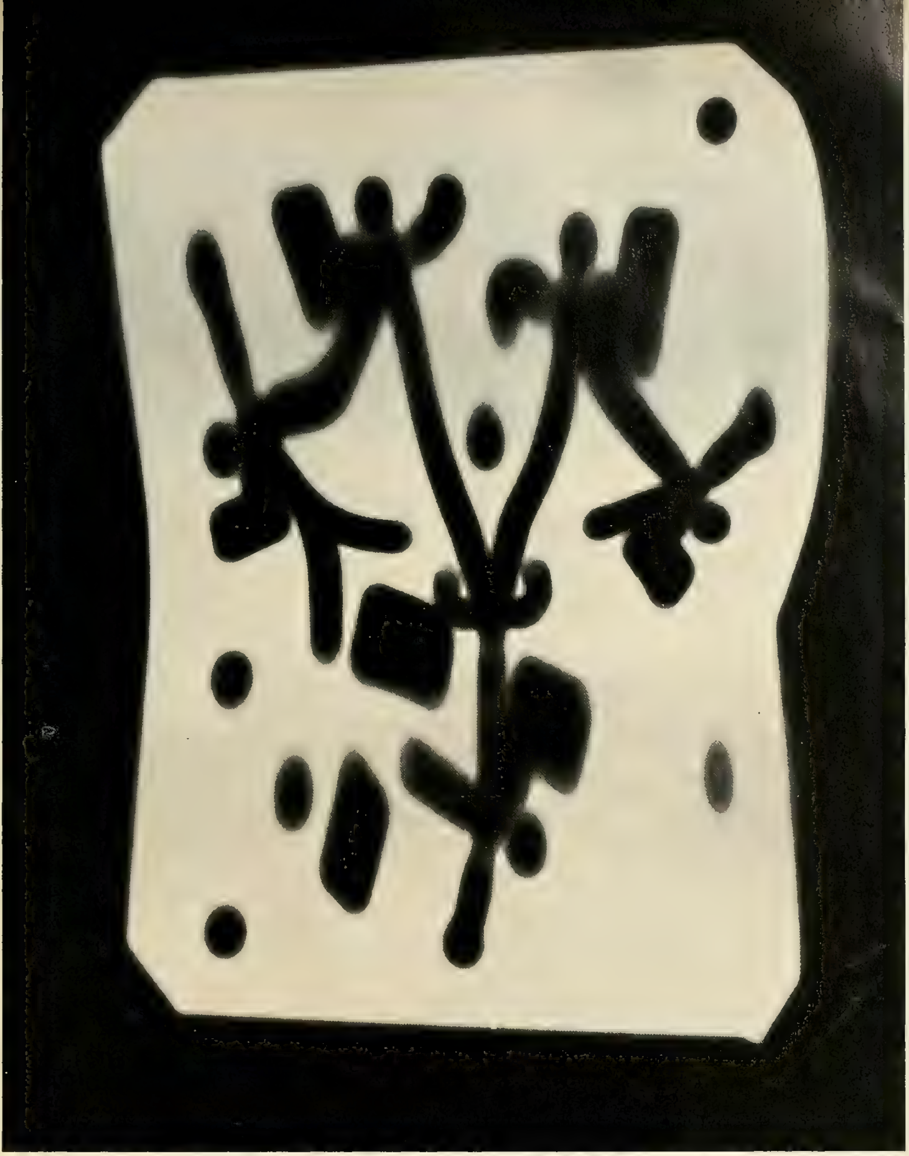
Silicon Converters

Pioneer Magnetics, Inc., has announced the PM 1300 line of Magacycler precision frequency to voltage converters.

The silicon device features a linearity of better than 0.1% and temperature stability of ±0.01%/°C for standard units and less than ±0.001%/°C for the gold line units. Long-term drift is less than ±0.05% per week; output impedance is less than 0.2 ohms.

Other characteristics include an operating range from 15 cps to 100 kc. Temperature range is —50° to 72°C. Input signals of 5mv to 20v are accommodated regardless of waveform. Outputs of 0 to 10v dc at 0 to 20 milliamps are standard, with higher powers available.

Circle No. 160 on Subscriber Service Card



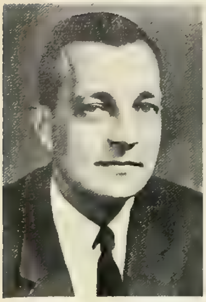
MISSILES AND ROCKETS SPECIAL REPORT:

FLUIDICS

HISTORY, GROWTH, STATE OF THE ART AND APPLICATIONS • PRESENT AND FUTURE MARKET POTENTIAL • PRESENT AND FUTURE EXPENDITURES • DESCRIPTION OF R & D EFFORTS OF PARTICIPANTS IN THE FIELD COVERING: Size of effort based on in-house and contract R & D programs • Technological approach — including material, fabrication, technique, components and/or systems types • Direction of effort —across-the-board research or specifications applications • Accomplishments to date.

Publishing date: February 8, 1965 **Closing date: January 25, 1965**

names in the news


WILLIAMS

HECK

THOMPSON

BRINKERHOFF

GRIMES

Percy L. Spencer: Retired from Raytheon Co., Lexington, Mass., in December. Formerly a vice president and board member, he will remain on the board and continue as consultant to the firm.

Howard R. Hawkins: Elected executive vice president and member of the board of directors of Radio Corp. of America, RCA Communications, Inc., New York City. He was formerly vice president and general attorney. He succeeds **Sidney Sparks,** who retired December 1.

Dr. Van Zandt Williams: Appointed director of the American Institute of Physics, effective April 1. **Dr. Ralph A. Sawyer,** chairman of the governing board and acting director since Oct. 1, will continue as chairman.

John J. Giba: Promoted to vice president and general manager of the Tele-Dynamics Division of American Bosch Arma Corp., Garden City, N.Y. He was formerly general manager of Tele-Dynamics.

John H. Heck: Appointed manager of procurement for the Communications Satellite Corporation, Washington, D.C. He was formerly manager of contract administration at Hoffman Electronic Corp.

Jason Weisman: Named vice presiden of Ion Physics Corp., Burlington, Mass He has been manager of operations fo the firm since 1960.

Dr. Maarten Schmidt: Received th Helen Warner Prize of the America Astronomical Society for his spectroscopi studies of radio galaxies and quasi-stella radio sources (quasars). He is professo of astronomy at the California Institute o Technology and a member of the staff o the Mount Wilson and Palomar Observatories.

Dr. R. J. Thompson, Jr: Named vice president and director-research of Rocketdyne, a division of North American Aviation, Inc. He will direct research in such fields as basic sciences and propulsion systems development.

Edgar W. Brinkerhoff: Elected president of Tel-Instrument Electronics Corp., Carlstadt, N.Y. He was one of the founders of the company established in 1947.

Peter James: Appointed vice president-management systems of the William C Allen Corp., Washington, D.C. He was formerly with the Diebold Group, Inc.

Barney Hayden: Named executive vice president of Greer Hydraulics, Inc., Los Angeles. He is also a member of the board of directors of Greer and vice president and board chairman of Precision Sheet Metal, Inc.

Philip L. Grimes: Elected president of California Testing Laboratories, Inc., Los Angeles. He has been with the company since 1940.

Harry D. Kierman: Named vice president and treasurer of the Aero Service Division of Litton Industries.

T. C. Runion: Assumed additional responsibilities as vice president of a newly established nuclear chemistry group for W. R. Grace & Co.'s Davison Chemical Division. He is also president of Nuclear Fuel Services, Inc, a majority owned subsidiary of W. R. Grace & Co.

WHAT ELSE PROVIDES UNFAILING POWER, QUIET AND POSITIVE ACTION BUT IS LIGHT WEIGHT AND REQUIRES NO MAINTENANCE?

The answer is: **ARLIND'S wide range of PYROTECHNIC POWER COMPONENTS**

- meeting or exceeding ordnance requirements
- designed to customer specifications
- initiation systems and components . . . triggered either electrically, mechanically or by air pressure
- Versatile: liquid and gas valves to 5000 PSI — orifice sizes from 1/16" to 8" . . . cable and rope cutters with capacities from 1/8" to 2½" dia. . . . also . . . Thrusters, Gas Generators, Explosive Bolts, Primer Cord Initiators, Igniters, Bellows Motors, Miniature Piston Actuators, Fuses, Firing Devices, etc.

ARLIND'S RELIABILITY, VERSATILITY AND CAPABILITIES (RANGING FROM 100,000 UNITS FOR ORDNANCE USE TO 1 UNIT FOR MISSILE OR SPACE APPLICATIONS) ARE UNSURPASSED IN THE DEVELOPMENT, ENGINEERING AND MANUFACTURE OF PYROTECHNIC POWER COMPONENTS.

Write for information regarding your specific requirements

ARLIND COMPONENTS, INC.
111 CLINTON ROAD, FAIRFIELD, N. J. • (201) 226-2219

Circle No. 10 on Subscriber Service Card

let us move with you!

Six Weeks Is Required
o Change Your Magazine Address

regulation of the Post Office requires that you
y extra postage if copies of

MISSILES AND ROCKETS

e forwarded to you at your new address. Copies
ll not be forwarded free and we cannot replace
t copies. To insure delivery at your new ad-
ess please notify us at least six weeks in ad-
nce of your moving. Send us your old and new
dress, and, **if possible, the address label**
om your last issue . . . include your postal
ne or zip number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

◆ ◆ ◆

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; STerling 3-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; YUkon 6-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, California 90210—9301 Wilshire Blvd.; CRestview 4-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

Detroit, Michigan 48237—21990 Greenfield Road, Oak Park, Mich.; 547-8880
Michael Rouff

Chicago, Illinois 60601—1 East Wacker Dr., Room 1522; 321-1444
Charles E. Durham, Jr.

Miami, Florida 33022—P.O. Box 890, Hollywood, Fla.; Wilson 7-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Geneva, Switzerland—10 Rue Grenus; Geneva 321044

Paris, France—11 Rue Condorcet; TRU 15-39

—when and where—

JANUARY

New York Academy of Sciences Conference on Civilian and Military Uses of Aerospace, Waldorf-Astoria Hotel, New York City, Jan. 11-14.

Eleventh National Symposium on Reliability and Quality Control, sponsored by the American Society for Quality Control and the Institute of Electrical and Electronics Engineers, Fountainebleau Hotel, Miami Beach, Jan. 12-14.

The Advanced Incentive Contracting Seminar, sponsored by the National Defense Education Institute, Houston, Jan. 13-15.

1965 Government-Industry Forum, sponsored by the National Electrical Manufacturers Assn., New Orleans, Jan. 18-19.

International Symposium on Solar Radiation Simulation, sponsored by the Institute of Environmental Sciences and the ASTM, International Hotel, Los Angeles, Jan. 18-20.

Conference on Quantitative Analysis and Evaluation for Production Activities, sponsored by Purdue University, Lafayette, Ind., Jan. 20-22.

Winter Meeting of the National Society of Professional Engineers, Jung Hotel, New Orleans, Jan. 20-23.

"The Case for Impure Research," lecture sponsored by the Advanced Research Projects Agency, The Pentagon, Washington, D.C., Jan. 21.

National Symposium on Hydrocarbon Analysis, sponsored by the ASTM, Sheraton-Lincoln Hotel, Houston, Jan. 22-23.

Symposium on Fundamental Phenomena in the Material Sciences, sponsored by the Ilikon Corp., Sheraton Plaza Hotel, Boston, Jan. 25-26.

Second Annual Aerospace Sciences Meeting, sponsored by the AIAA, New York Hilton, New York City, Jan. 25-27.

Joint Annual Meeting of the American Mathematical Society and the Mathematical Association of America, Univ. of Colorado, Denver, Jan. 25-30.

Second Winter Power Meeting of the Institute of Electrical and Electronics Engineers, Statler-Hilton, New York City, Jan. 31—Feb. 5.

FEBRUARY

Reinforced Plastics Division Conference, sponsored by the Society of the Plastics Industry, Edgewater Beach Hotel, Chicago, Feb. 2-4.

Winter Convention on Military Electronics, sponsored by the Institute of Electrical and Electronics Engineers, Ambassador Hotel, Los Angeles, Feb. 3-5.

Unmanned Exploration of the Solar System, sponsored by the American Astronautical Society, the American Astronomical Society, American Geophysical Union, American Institute of Biological Sciences, IEEE and AIAA, Denver Hilton Hotel, Feb. 8-10.

Advertisers' Index

AEROJET-GENERAL CORP. .... Agency—D'Arcy Adv. Co.	48
AMERICAN AIR FILTER CO., DEFENSE PRODUCTS GROUP .... Agency—Zimmer, McClaskey, Lewis, Inc.	6
APPLIED PHYSICS LABORATORY, THE JOHNS HOPKINS UNIVERSITY....... Agency—S. G. Stackig, Inc.	11
ARLIND COMPONENTS, INC........... Agency—Associated Graphics Inc.	44
BOEING CO., THE, AERO-SPACE DIV... Agency—Campbell-Ewald Co.	38
CANOGA ELECTRONICS CORP......... Agency—Jordan Farrell Adv. & Marketing Services	3
CHANDLER EVANS CORP., COLT INDUSTRIES .... Agency—G. F. Sweet & Co., Inc.	4
CONAX CORP., EXPLOSIVE PRODUCTS DIV. .... Agency—B. P. Meyer Associates, Inc.	42
DELTA AIR LINES, INC............... Agency—Burke Dowling Adams, Inc.	41
DOUGLAS AIRCRAFT CO., INC........ Agency—J. Walter Thompson Co.	7
INTERNATIONAL STEEL CO., LINDSAY STRUCTURE DIV. .... Agency—Keller-Crescent Co.	35
SANGAMO ELECTRIC CO. .... Agency—Winius-Brandon Co.	2
SPACE TECHNOLOGY LABS., A SUB. OF THOMPSON RAMO WOOLDRIDGE INC. .... Agency—Fuller & Smith & Ross Inc.	8
SYSTRON-DONNER CORP. .... Agency—Bonfield Associates, Inc.	28
TROPEL, INC. .... Agency—Harry M. Clar & Associates	40
VARIAN ASSOCIATES .... Agency—Hoefer, Dieterich & Brown, Inc.	47

Paper Bear

LAST WEEK WE MENTIONED an article in the December issue of *Fortune* magazine by Charles J. V. Murphy. We would like to comment further on that article, since Mr. Murphy has assembled an interesting chronology of the Soviet ICBM effort as charted by Turkish radars and U-2 aircraft.

"Fortunately," writes Mr. Murphy, "a novel means for penetrating the Iron Curtain had come to hand. In the winter of 1954-55, at a village called Diyarbakir, situated in the mountains of Turkey that stare across the Black Sea, a full 660 nautical miles from Kapustin Yar, a small body of U.S. technicians began the construction in secrecy of the most powerful fixed-beam radar to be built until that time. . . . The antenna was half as long as a football field, and a considerable airlift was required to transport the structure, together with the necessary power units and other equipment, across the ocean. By the early summer of 1955, the installation was in operation, watching whatever arose above Kapustin Yar."

The assessment of the Russian missile effort established that Kapustin Yar was a test center only for rockets of intermediate and medium range, incapable of reaching the U.S. from Soviet launch sites. The big question, then, was where was the Russian ICBM test complex?

"In the early summer of 1957," says Mr. Murphy, "shortly after the U-2's began to operate out of Pakistan, the place was found. It was situated on the Trans-Siberian railroad, at a place called Tyura Tam, near the Aral Sea, about 680 miles from Kapustin Yar. Here was a large establishment, comparable to the missile and space testing center that the U.S. was constructing at Cape Canaveral. From here, the Soviet technicians were making ready to lob their high rockets toward Kamchatka Peninsula, some 3,000 miles to the east, and later into the Pacific Ocean. This discovery of Tyura Tam preceded by some weeks the first successful Soviet firing of an ICBM, which occurred and was announced to the world in August, 1957. The U-2 camera actually looked down on the first Soviet ICBM on its launcher. It also perceived on the same premises the elaborate preparations afoot for the *Sputnik* spacecraft that were launched a few months later, the first in October, the second in November."

The Soviets, in 1957-58, had a big jump on the U.S. in the missile field. The mammoth Russian ICBM's already were being deployed to the first operational squadrons. All evidence pointed to the fact that the Russian ICBM program was moving into a production stage with a high delivery capability. The U.S. Central Intelligence Agency reached the conclusion that the Russians, if they decided to go into all-out production, probably could deploy some 500 ICBM's by mid-1960. There was indeed a "Missile Gap" and every prospect that it would widen.

But as the U-2 photographs piled up, CIA was puzzled. There was no evidence of the large-scale production anticipated in estimates of Soviet capabilities. What had happened?

Mr. Murphy suggests that Premier Khrushchev had become aware of the military handicaps of the big, unwieldly, above-ground, liquid-fueled Soviet ICBM's and had called a halt to quantity production of these. This analysis makes sense. The U.S. already was aware of the deficiencies of its own early *Atlas* and *Titan* missiles and was pushing ahead with the solid-fueled *Minuteman* and *Polaris* systems.

Mr. Khrushchev was aware of these U.S. developments and it is logical to conclude that he realized the military weaknesses of missiles such as his early ICBM's, which, if anything, were more vulnerable than their U.S. counterparts. Yet today, U.S. intelligence does not credit the Soviet Union with a large build-up of ICBM's, placing the number at less than 200. What has happened?

It is at this point that Mr. Murphy's reasoning begins to fall down. He drops into the familiar trap of concluding that the Soviet Union is an impoverished nation, incapable of supporting a large-scale ICBM effort.

He says of Mr. Khrushchev: "His enormous capital investment in long-range nuclear rocketry, far from making the Soviet Union the strongest military power on Earth, as he reasoned it would, had instead weakened the underpinnings of the entire national and international structures of Communism. . . . On the economic side, this ill-timed, lop-sided investment in military technologies had critically starved the industrial sector, especially the light consumer industries.

"At this point, a chain reaction set in. The Soviet industrial growth rate began to slacken; agriculture failed catastrophically; and the long-overdue improvements in the standard of living could not be made."

Just how a decision *not* to go into large-scale production of the ICBM's could slow down the growth rate and bring on crop failures, Mr. Murphy fails to explain. Nor does his theory take account of the fact that the Soviet living standards have continued to rise.

WE WOULD LIKE TO SUGGEST a more plausible explanation. Mr. Khrushchev, having realized the desirability of the smaller, solid-fueled ICBM, faced a problem. The Soviet missile background, culled from German scientists, was based entirely on World War II liquid technology. The know-how in solids was missing. It has long been established that the Soviet chemical industry is one of the weak spots of the industrial structure. We ourselves were writing in detail on this as much as six years ago. Mr. Khrushchev, thus, was forced to mark time while this deficiency was remedied, if indeed it has been.

The Cuban missile venture then becomes not an adventurous gamble but a logical effort to move the Soviet intermediate missiles to a location where they could, at least temporarily, fill the ICBM gap.

If this is true, the Soviet ICBM build-up will be resumed when the solid technology is developed—and we must be ready for it.

William J. Coughlin

VARIAN-POWERED
HAYSTACK RADAR
TO MEASURE VENUS
...AND MORE DISTANT PLANETS

stack, the new microwave research facility of MIT's Lin-
n Laboratory, will soon begin radar studies of the planet
us and others. In addition to spanning the 29.5 million
es between Lexington, Massachusetts and Venus, the
stack system will provide valuable, practical guidance in
design of future high-performance microwave facilities.
radar phase of Haystack embodies a recently developed

Varian five-cavity klystron, the VA-879 (driven by a Varian VA-617 TWT). Power output of the klystron is 100 kW CW at X-band. It has a gain greater than 50 db, a 3 db bandwidth of about 40 Mcps, and over-all efficiency greater than 40 per cent. Yet it is only 28 inches long.

Haystack is one more example of Varian's ability to power the world's most advanced microwave systems.

VARIAN TUBE division
associates

Executive Offices: 611 Hansen Way, Palo Alto 10, Calif. ☐ Microwave Tube Group: Palo Alto Tube Division ☐ Solid State Products ☐ Bomac
Division ☐ SFD Laboratories, Inc. ☐ Semicon Associates, Inc. ☐ Varian Associates of Canada, Ltd. ☐ In Europe: Varian A.G., Zug, Switzerland

Circle No. 11 on Subscriber Service Card

THE MOON IS MADE OF OXYGEN

A dramatic new process developed by Aerojet under the sponsorship of NASA literally enables scientists to turn the surface of the moon into oxygen. Utilizing metallic silicates generally acknowledged to be present in the lunar environment, the Aerojet Carbothermal Process recovers the bound oxygen contained in such minerals as basalt (shown above), granite and tektite. The presence of lunar water is not required. ■ Aerojet's comprehensive, innovative experimental program in the utilization and exploitation of lunar resources will result in the establishment of chemical plants for the production of propellant and life-support oxygen for advanced lunar bases, moon-earth transport and planetary exploration. ■ A joint NASA-OART Aerojet-General research program is leading toward the development of an 8,000 pound plant capable of producing 6,000 pounds of oxygen per month. *Deployment of a lunar chemical plant based on Aerojet's process and capable of producing 12,000 pounds of oxygen per month can save the national space effort over $350,000,000 a year.*

AEROJET
GENERAL TIRE
GENERAL
TM
VON KARMAN CENTER/Azusa, California

JANUARY [illegible], 1965

missiles and rockets

HE WEEKLY OF ADVANCED TECHNOLOGY

JAN 1965
HOUSTON
1234567

U.S. AIR FORCE
TITAN III

an III-C Solid Motors at Cape Kennedy

OD Studies City-Defense A-ICBM ......

rescription for Industry Stabilization ....

ORL Electronics May Be Off-the-Shelf ..

INTEGRATED CAPABILITY

HIGH-RELIABILITY COMPONENTS • ELECTRONIC SYSTEMS • ORDNANCE

EG&G electronic systems capability extends from miniaturized Exploding Bridge Wire systems to the nation's largest analog telemetry system, now in operation at AEC's Nevada Test Site.

EBW timing, firing and ordnance capabilities are an outgrowth of EG&G's unique 17-year involvement in AEC and NASA nuclear weapon and nuclear rocket engine programs.

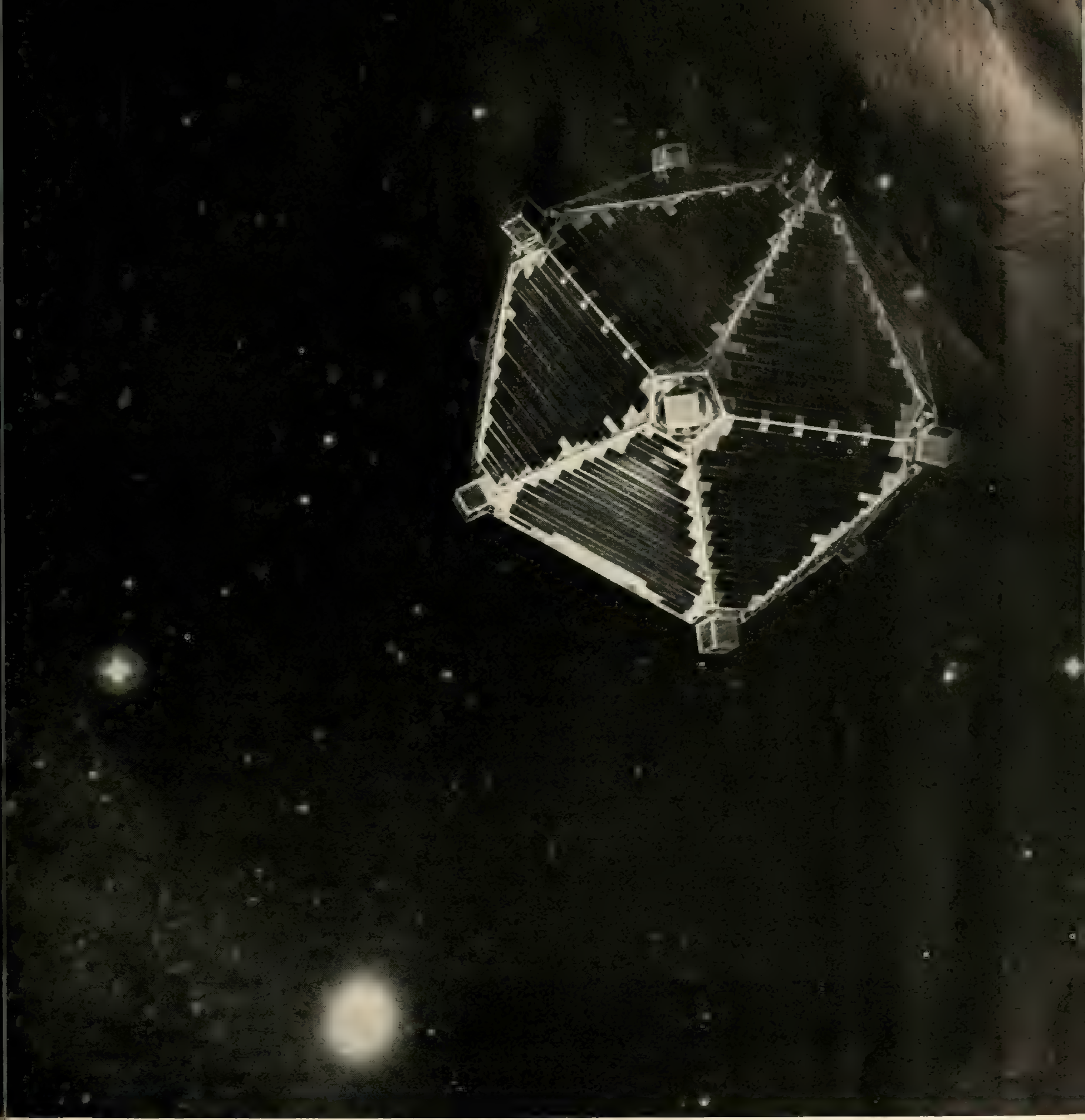
In a typical EG&G/EBW system, code protected signals induce reliable command firing to energize an ordnance actuator or detonator. Low energy consumption during long no-fire periods and positive all-fire response to the prescribed firing signal assures EBW action and ordnance detonation. Proven no-fire capability is established in intense radiation environments because of EG&G's exclusive Krytron trigger tube.

EG&G provides complete EBW systems design, development, production and evaluation. The company designs and manufactures the critical EBW components, including the Krytron cold cathode trigger tube, triggered spark gaps, high efficiency trigger and power transformers, squibs and detonators.

This integrated capability can meet any or all phases of your EBW requirements. For complete information, program managers now contemplating changeover to EBW, or designing EBW systems or components into a new system, are invited to write EBW Systems Engineering, Edgerton, Germeshausen & Grier, Inc., 160 Brookline Avenue, Boston, Massachusetts. Or to phone 617-267-9700 collect. TWX: 617-262-9317.

EG&G INC.

Circle No. 1 on Subscriber Service Card



15 months ago they gave it 6 months to live.

When the first Vela nuclear detection satellite* was launched, its lifespan was estimated at six months. That was in October, 1963. Now, fifteen months later, it is still operating perfectly, monitoring radiation levels in outer space.

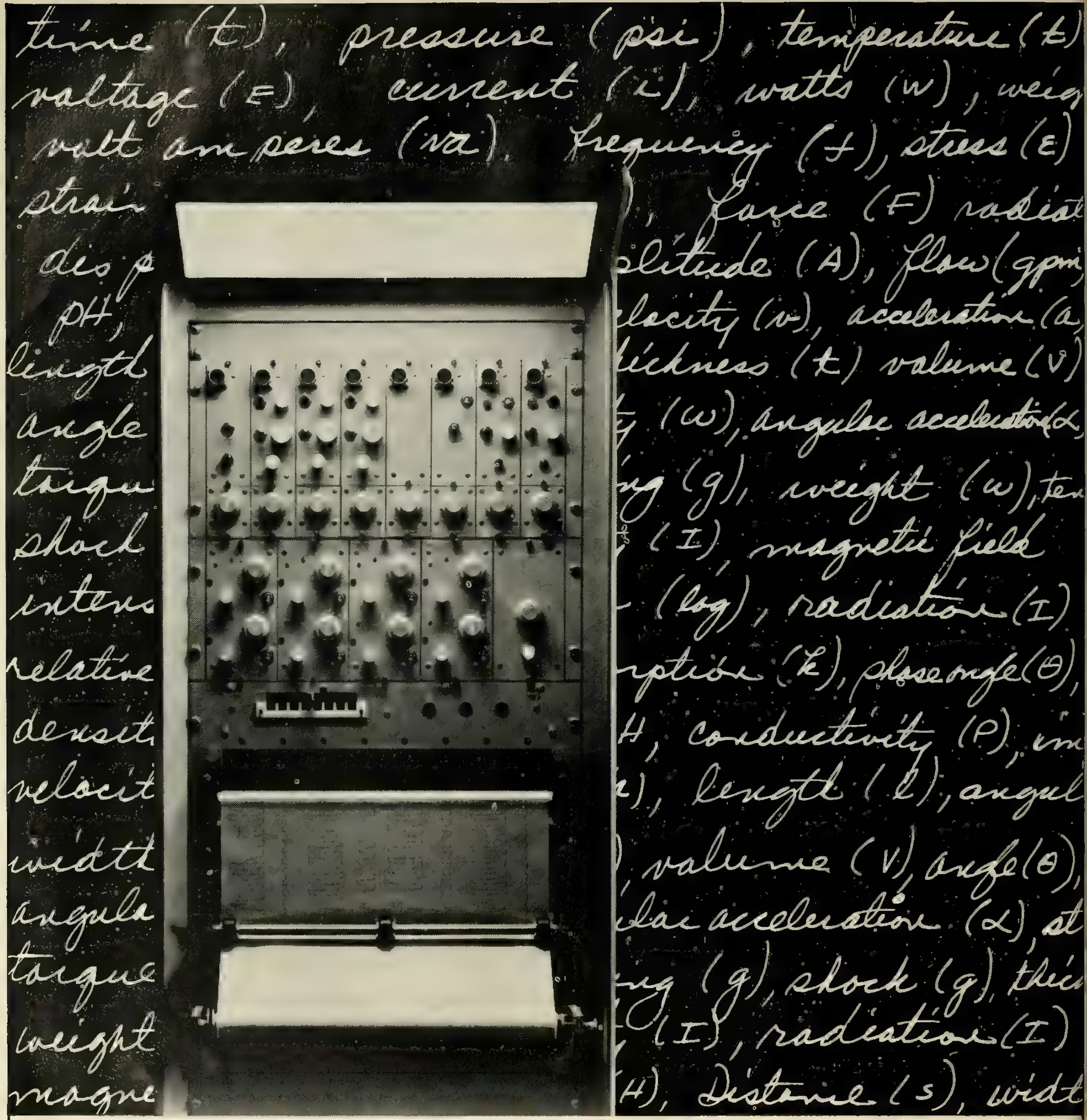
Sandia Corporation developed the miniature data-handling computer for this sentry in the sky. To meet the rugged requirements of blast-off and space environment, they designed in the most reliable components available, including more than 1,000 transistors and 3,000 diodes from Fairchild.

FAIRCHILD
SEMICONDUCTOR

*Vela is an ARPA-AEC sponsored project of the Air Force, Space Technology Laboratories, Sandia Corporation and the Los Alamos Scientific Laboratory.

FAIRCHILD SEMICONDUCTOR/A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION/313 FAIRCHILD DR., MOUNTAIN VIEW, CALIF./962-5011/TWX: 910-379-6435

Circle No. 2 on Subscriber Service Card


time (t), pressure (psi), temperature (t)
voltage (E), current (i), watts (w), weig
volt amperes (va), frequency (f), stress (E)
strain
), force (F) radiat
disp
plitude (A), flow (gpm
pH,
locity (v), acceleration (a
length
ickness (t) volume (V)
angle
(ω), angular acceleration (α
torque
ng (g), weight (w), te
shock
(I), magnetic field
intens
(log), radiation (I)
relative
ption (k), phase angle (θ),
densit
H, conductivity (P), im
velocit
), length (l), angul
width
, volume (V), angle (θ),
angula
lar acceleration (α), st
torque
ng (g), shock (g), thic
weight
(I), radiation (I)
magne
H), Distance (s), widt

Offner Recorders are adaptable

A single Type R Offner Dynograph® Oscillograph can be quickly converted to record any physical or physiological phenomenon. All applications accommodated by a simple interchange of plug-in input couplers that cost only about $60 per channel.

Type R Dynograph® Specifications

Sensitivity Range	1 μv/mm — 5 v/mm
Frequency Response	DC to 200 cps
Response Time	2.5 msec
Drift (shorted input)	1 μv equiv. input/hr.
Warm-up Time	Instantaneous
Recording Amplitude	7 cm (curvilinear) 6 cm (rectilinear)
Linearity	0.5% for central 5 cm (curv.) 1.0% for central 5 cm (rect.)
Input Impedance	2.5 megohm
Input Couplers	Complete line
Number of channels	to 24
Approximate cost per channel	$1,000

063-337

For complete data on the Dynograph line, see your Offner representative or write us.

Beckman® INSTRUMENTS, INC.

OFFNER DIVISION
Schiller Park, Illinois

International Subsidiaries: Geneva, Switzerland; Munich, Germany; Glenrothes, Scotland

Circle No. 3 on Subscriber Service Card

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 3 January 18, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors
Charles D. LaFond................Electronics
William S. Beller................Engineering

Associate Editors
Lawrence J. Curran......Assistant Managing Editor
Heather M. David..................Space Medicine
Michael Getler.........................Electronics
Russell Hawkes..........................Industry
John F. Judge.................Advanced Materials
Robert L. Parker....................Copy Editor
Rex Pay...............................Electronics
Hal Taylor...............................NASA
James Trainor...........................Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach...................Art Director
Donald Strickland...........Assistant Art Director
Suzanne Montgomery........ ...Editorial Assistant
Sally Fosnight ....Editorial Assistant

BUREAUS
LOS ANGELES.....9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks................ ..Bureau Chief
NEW YORK....................20 East 46th Street
Michael Getler
CAPE KENNEDY ....507 Orange Ave.
Chris Butler.....................Merritt Is., Fla.
MIDWEST ....423 N. Quentin
John L. Zimmerman ....Wichita, Kan.
PARIS.........................11 Rue Condorcet
Jean-Marie Riche
GENEVA..........................10 Rue Grenus
Frank G. McGuire

EDITORIAL ADVISORY BOARD
Dr. Peter Castruccio **Alexander Satin**
Conrad H. Hoeppner **Vice Adm. H. Sanders (ret.)**
Richard F. Gompertz

•

James W. Claar
Publisher

. C. Boughton............National Sales Manager
aul B. Kinney........Eastern Advertising Manager
dwin J. Denker, Jr.....Western Advertising Manager
enneth C. Blanchard.Marketing & Research Director
ohn N. Carlin..............Director of Circulation
addy Nelson................Circulation Promotion
. Virgil Parker............Director of Production
arbara Wiener........Advertising Services Manager

Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

resident.... .... **Wayne W. Parrish**
enior Vice President .... **Louis C. James**
ice President................... **Fred S. Hunter**

THE COVER

Locomotive prepares to leave after storing first Air Force Titan III-C solid motor segments to arrive at Cape Kennedy's integrate-transfer-launch area from United Technology Center's Sunnyvale, Calif., facility. Locomotives are operated by crews from Martin Co., prime for the Titan III.

JANUARY 18 HEADLINES

RFP's to Industry Initiate Voyager Development **10**
Terminal Intercept City Defense Plan Studied **13**
Navy's Transit Satellite System Now Operational **14**
Resiliency of U.S. Strategic Force Emphasized **15**
Satellite Relays Valuable Solar Radiation Data **15**
Military Comsats To Have Three-Year Lifetime **16**
Missile Money Pared in DOD's FY '66 Budget **16**
Study Says Aerospace No Longer Growth Industry **17**

SPACE ELECTRONICS

MORL Subsystems To Be Within State of Art **22**

SPACE MEDICINE

Grumman Tests Aimed at Reducing Rotation Problems **26**

LUNAR MAPPING

Large Number of 'Hot Spots' Found in Moon Study **28**

SPACE SUPPORT

Facility Tests Solids in Operational Environment **31**

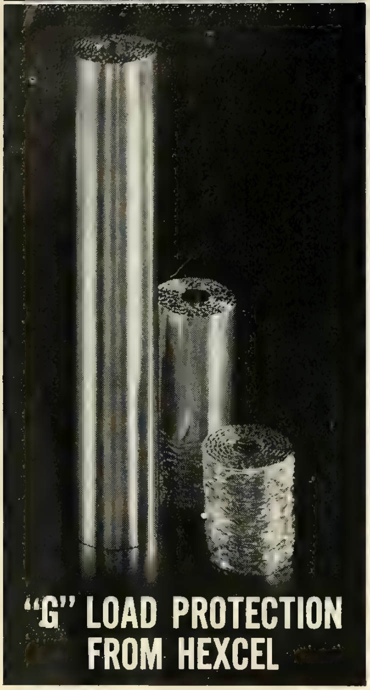
SPACE EXPLORATION

Advanced Mars Life Probes Await Better Boosters **32**

DEPARTMENTS

Letters **6**
The Countdown **9**
The Missile/Space Week ® **10**
Technical Countdown **21**
The Industry Week **37**
Contracts/Procurements **38**
Products & Processes **40**
Names in the News **44**
When & Where **45**
Editorial **46**

48,000 copies this issue



- This material gives more efficient energy absorption for high slenderness-ratio tube forms than any material known.
- It is cylindrical aluminum honeycomb.
- It is called TUBE-CORE®.
- It can be designed for crush strengths ranging from 40 to 4,000 p.s.i., to suit most any environment and life expectancy.
- It requires no lubrication and costs far less than hydraulic units.
- TUBE-CORE® is custom-designed to meet exact energy absorption requirements.

For descriptive literature, call or write to:

HEXCEL PRODUCTS INC
World leader in research and manufacture of honeycomb core materials.

Executive Offices: 2332M Fourth St., Berkeley 10, Calif.

Applications Engineering Offices: Huntsville, Ala., (205) 536-0936; Inglewood, Calif., (213) OR 8-4121; Havre de Grace, Md., (301) WE 9-2900; Arlington, Tex., (817) CR 4-2578

Circle No. 4 on Subscriber Service Card

letters

Need for Shelters

To the Editor:

Congratulations on the Jan. 4 editorial ("The Threat"). We badly need an adequate civil defense shelter program. This need has increased with development of nuclear weapons by Red China.

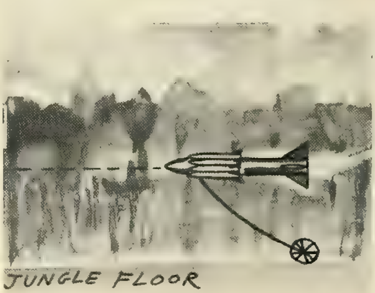
Much has been written on civil defense and shelters. Several Congressional committees have held hearings on this and related subjects. These hearings have been published by the U.S. Government Printing Office. Also, a great deal of other material in this same field has been published by GPO, much of it from the Office of Civil Defense (now the Civil Defense Office). GPO publishes a free price list—PL 84 *Atomic Energy and Civil Defense*, which may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402.

David W. Johnston,
Washington, D.C.

Big Bull Missile

To the Editor:

After considering the system mentioned in the article "Low-Cost Missile Has Dual Capability" (M/R, Dec. 14, p. 34) we have reached the conclusion that the cost estimate is indeed conservative. Enclosed is a breakdown of the cost of the components that might be used in such a system. We fear that with a stated price of $300 per missile most planners would become uninterested; we don't think that this is a fair price and instead submit our estimate.



The sketch indicates the type of terrain avoidance gear that could be used compatibly with the stated price. This might also double as the altimeter if a set of microswitches are connected between the main frame and the wheel-supporting rod.

Lloyd G. Knowles, Gerald C. Martin,
Richard F. Mucci, Sabina H. Saib
Johns Hopkins University
Applied Physics Laboratory
Silver Spring, Md.

COMPONENT LIST FOR BIG BULL MISSILE SYSTEM

MOTHER MISSILE			
(1)	**Baby Harness for 6 Satellite Projectiles**		7.47
(2)	**Servo-Actuated Elevons** (Honeywell Thermostat Type)	at 8.40 ea	16.80
(1)	**Optical Altimeter (Adaptive Brownie "Starflash")**		7.50-8.00
(1)	**Terrain Avoidance Gear**		
	Wheel		8.98
	Rod/Bearing		4.37
(2)	**Mirrors, Beam Split Type**	at 0.15 ea	.30
(1)	**CW Laser** Use Cheap Solid-State Ruby—Perhaps "Star-of-India" Dyed Red		13.88
(4)	**Coherent Solid-State Detectors** 1N 276B	at 0.37 ea	1.48
(1)	**Plastic Gas-Activated Gyro** (Ideal Toy Co.) (Hot Air Not Included)		14.17
(1)	**Solid Propellant Rocket** (Perhaps Modify Old Atlas "D")		G.F.E.
(10)	**Paper Vector Control Rockets** (Cherry Bombs—Sold Only in Va.)	at 0.25 ea	2.50
(1)	**High-Reliability Zippo Lighter** Mounted on Rotary Solenoid (Used to actuate items above)		18.00
(1)	**Sustainer Rocket Casing** (A. C. Gilbert Co.)		11.36*
(1)	**Monkey—Use Local Jungle** (for integrated maintenance)		J.F.E.
(1)	**Test Set** (44 Viet-Cong Prisoners)		G.F.E.
*Price not firm	Approximate Total Mother Missile Cost		$117.01
Satellite Projectile—6 per Mother Missile			
(6)	**Proximity Fuzes** (antennae from common grasshoppers appropriately monitored)	at 0.316 ea	0.19
(6)	**Warheads** Each with 74,916 compressed ping-pong balls with porcupine quills added at a ratio of 1/24 to 1	at 13.33 ea	80.00
(6)	**Rocket Casings** Wash. Post yields 3 units (Sunday) N.Y. Times yields 8 units (Sunday) Chicago Trib yields nil (any day)	at 0.25/3	0.50
		Total Cost for 6 Satellite Projectiles	$80.69
		TOTAL SYSTEM COST	$197.70

UP?
UP?
UP?
UP?
UP?

NOW, WHO THOUGHT THAT

eons, man has looked up to the stars
ndering...questioning.
w, at last, questions of what lies beyond
arthest gaze are being answered by
ive, down-to-earth thinking.
Lockheed Missiles & Space Com-
in Palo Alto and Sunnyvale, Cali-
a, a dedicated team of POLARIS mis-
and AGENA satellite specialists
nue to evolve new concepts—further
nding man's outward reach. These
ntists and engineers, schooled in
logic, skilled in shirt-sleeve know-how, explore a thousand thoughts each day.

What might you *think up* in such distinguished company?

If you have a degree in AE, ME, EE, Physics or Applied Mathematics, with a background in vehicle dynamics and astrodynamics, we invite your inquiry. A working knowledge of calculus of variations, gradient methods, dynamics programming or Pontryagins theorems also would be helpful.

Write for a brochure that gives a more complete look at Lockheed. *Address:* Lockheed Missiles & Space Company, Dept. 102, P. O. Box B-504, Sunnyvale, California.

LOCKHEED
MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

AN EQUAL OPPORTUNITY EMPLOYER

A NEW CATADIOPTRIC LENS

This new computer-designed lens assembly was developed to withstand severe environmental conditions such as those existing in airborne or spaceborne, television tracking and guidance equipment. Its resolution is diffraction limited.

General Electrodynamics Corporation will provide, on short notice and with minimum development cost, focal lengths and effective apertures to fit YOUR application.

Environmental Characteristics:

Vibration:	10g from 10 cps to 2,000 cps
Shock:	100g for 5 ms
Temperature:	—65°F to —250°F without refocusing

For integrated systems employing either optics, sensors or processing electronics, or any combination to meet your requirements, write or call

GENERAL ELECTRODYNAMICS CORPORATION

4430 FOREST LANE • GARLAND, TEXAS • BROADWAY 6-1161

Circle No. 5 on Subscriber Service Card

The Countdown

WASHINGTON

NASA Asking $5.26 Billion for FY '66

Space agency's Fiscal Year 1966 budget request will be $5.26 billion—only slightly above last year's $5.25-billion funding level appropriated by Congress. Two major items will be $1.12 billion for the *Apollo* spacecraft and $242.1 million for the two-man *Gemini* spaceflight. Remainder of the manned spaceflight budget of slightly more than $3 billion will fund the *Saturn V* and *Saturn IB* launch vehicle programs.

Transit: What Wasn't Said

Last week's announcement on *Transit* failed to mention a few things that are nonetheless part of the record. Originally, the system was to have been operational in late 1962. Its weight was to have been 100 lbs. or less, to enable use of the cheaper *Scout* booster rather than *Thor-Able Star*, which is overpowered for the job. Its lifetime was to have been 3-4 years. None of these objectives were met.

OSO Heads Burgeoning Cape Launch Slate

NASA plans to launch an *Orbiting Solar Observatory* (*OSO*) early next month. Also on the schedule is the *Ranger VIII* spacecraft in mid-February, with the *Ranger IX* due to go about a month later. The fifth *Centaur* launch is now scheduled for March. All flights will be from Cape Kennedy.

Comsat International Agreement To Expand

Within the next few weeks as many as 10 additional nations are expected to sign the interim international communications satellite agreement, according to Comsat Corp. technical coordination assistant Edwin J. Istvan. Ten additions would bring the total to 30 countries. Istvan also told the N.Y. Academy of Sciences meeting that CSC has raised its expectations of the efficient use of multiple-access techniques—it now feels that with broadband repeaters some 35% of the satellite's effective channel capacity, utilizing only a single carrier, would be useable with as many as 16 carriers exercising it simultaneously.

Booster Hearings Loom Again

Big-booster briefings once more are at the top of the agenda at the Senate Space Committee. The group is working to fix a date soon that will suit top-ranking witnesses and committee members. The committee says, however, that the closed-door briefings actually will serve as a progress report—since although no hearings were held last year, the agencies involved were put on notice of the committee's interest and have taken steps to initiate coordination.

On-Again, Off-Again Space Message

The White House was dissembling a bit last week when it announced that, contrary to previous reports, no special message on space would be submitted to Congress. Instead, it said, the NASA budget would be submitted along with the rest of the Federal budget on Jan. 25. It explained that the special message and NASA budget were not sent to the Hill earlier because the space agency requested that they be delayed. What actually happened was that the White House misconstrued a simple cover letter on the NASA budget as representing a special message.

No-Missile/Space-Strike Bill Pending

Legislation that would make it illegal to strike a strategic defense facility has been introduced by Sen. John L. McClellan (D-Ark.). Language apparently would cover almost all missile/space companies, although they would have to be so designated by the Secretary of Defense. In event of a dispute, the Secretary would have the power to set up an emergency board to conduct hearings and make decisions binding on both parties for one year.

INDUSTRY

Impulse-Controllable Solid Demonstrated

A lightweight solid motor that is impulse-controllable on demand has "arrived," says Lockheed Propulsion Co., with successful test of a unit containing 40 solid-propellant wafers. In a demonstration for AF Rocket Propulsion Lab, the motor—about 10 ft. long and 2 ft. in diameter—was operated in eight separate firing sequences of five pulses each over an elapsed-time period of 26 hours. Each wafer exceeded 1,000 lbs. of thrust. Equipped with some form of thrust vector control, such a motor could change speed and direction. The Air Force indicates the concept will be used for air-launch applications—possibly in the *Short-Range Air-launched Missile (SRAM)*. LPC is scheduled to deliver an identical motor within a few weeks for testing applicability to *SRAM*-type missiles in altitude chambers at Arnold Engineering Development Center.

Armed Helicopter Studies Continue

Army is extending study work being done by Philco's Aeronutronic Div. on the use of *Shillelagh* as armament for a weapons helicopter. Consideration is also being given to extending the Hughes Aircraft Co. contract to study *TOW* for the same application. Both missiles are being tested on the UH-1B helicopter.

Three Firms Form Ocean Systems, Inc.

Union Carbide Corp., General Precision Equipment Corp., and Edwin A. Link, a leading oceanologist and marine inventor who has also won wide recognition for his work on aerospace simulators, have formed Ocean Systems, Inc., a new firm aimed at commercial development of underwater services and supporting hardware systems. Four members of the Navy's deep submergence systems review group, which was formed in 1963 after the loss of the USS Thresher, are now affiliated with the firm.

INTERNATIONAL

Decisive ELDO Meeting Set for Jan. 19

Many European observers believe that a meeting of the European Launcher Development Organization (ELDO) in Paris Jan. 19-21 may see an end of efforts to carry out a joint European research program under the ELDO aegis. Cost of participation in the program has climbed so much that several nations are bucking the increase in dues. Furthermore, the recent success of Italy's *San Marco* satellite launch, conducted in cooperation with NASA, is tempting European scientists toward similar bilateral arrangements with the U.S.—viewed as a far more economical approach.

RFP's Trigger Voyager Development

NASA has initiated development of *Voyager* with a request for design proposals from industry for the program's spacecraft bus and retro-propulsion system.

From the firms submitting proposals, two to four contractors are expected to be chosen. They will conduct design definition studies of the systems. The Jet Propulsion Laboratory (JPL) at Pasadena, Calif., will have management responsibility for the program.

The announcement was made by Dr. Homer E. Newell, associate administrator for Space Sciences and Applications, who said, "to assure the possibility of the Mars opportunity in 1971, planning for the *Voyager* must be undertaken now."

Newell stressed, however, that until completion of design definition there would be no approval to start hardware development. According to the Phase I procurement plan, one or two of the firms conducting the study will be given a follow-on systems design contract.

Selection of the spacecraft's prime contractor is expected in the spring of 1966. Eventual value of the program, also to include a landing capsule, is expected to exceed one billion dollars.

Previous *Voyager* studies have suggested a spacecraft bus weighing 1,500-2,000 lbs. and a retro-propulsion system weighing 2,000-3,000 lbs. The landing capsule might weigh up to 6,000 lbs.

Guidelines indicated the spacecraft bus might carry some 200 lbs. of scientific instruments for a useful lifetime in Mars orbit of some six months. It would carry all power, guidance and communications systems for the Earth-Mars transit and while orbiting Mars, could relay data from the capsule while it is on the Martian surface.

Proposals for design of the landing capsule are yet to come—probably late this year. A decision on which center is to manage that portion o the *Voyager* program still has no been made. Langley Research Center appears to have an edge in the competition, but Ames Research Center Goddard Space Flight Center an JPL are still in contention.

A potential new launch vehicle employing the *Saturn IB* and a *Centau* upper stage is being studied as th *Voyager* launch vehicle. Contractors are being asked to design a spacecraft system that could be flight tested during the Mars opportunity of early 1969 using either *Saturn IB* *Centaur* or the *Atlas-Centaur*.

Titan III-A Accuracy Champ

Launch of the *Titan III-A* on Dec. 10 may have gained the most accurate orbit ever achieved in the U.S. space program, according to Brig. Gen. Joseph S. Bleymaier of the Air Force's Space Systems Division.

The vehicle achieved an orbit with a 102-n. mi. apogee and a 99-n. mi. perigee against a planned 100-n. mi. nominal orbital altitude, Bleymaier said last week at the meeting of the New York Academy of Sciences (see p. 13). Deviation from a true circle was 0.00075 against a predicted value of 0.00050. Time for a single orbit was 88.2 min., within 0.04 min. of the time predicted.

Discussing growth potential of the *Titan III*, Bleymaier said studies would continue at both ends of the power spectrum—on the low end, adapting the *Agena* spacecraft to the *Titan III*, and on the high end, substituting segmented 156-in.dia. solid motor strap-ons for the presently planned 120-in.-dia. strap-ons of the *Titan III-C*.

Emphasizing that this was only in the study phase, Bleymaier said the 156-in. strap-ons could double the payload to in excess of 40,000 lbs. in near-Earth orbit.

The general told MISSILES AND ROCKETS that funds would be released soon to continue the series of 156-in. solid motor firings, which have been successful to date. The new tests are expected to include burn times that might be applicable to *Titan III* missions.

Polaris B-3 PDP Due Soon

The Navy has confirmed that it plans to begin program definition of the *Polaris B-3* early this year (M/R, Jan. 11, p. 13).

Lockheed Missiles & Space Co. will handle systems integration of the advanced *Polaris* as it did for the *A-1*, *2* and *3* versions. "Contractors for the development of two solid propellant motors will be selected following a competitive program definition phase," the Navy said.

Kiwi Destruction Test Success

A safety destruct test of the Kiwi B4E reactor was successfully completed Jan. 12 at Jackass Flats, Nev., by the Atomic Energy Commission (M/R, Jan. 11, p. 15).

The experiment resulted in an energy release of approximately 30,000 megawatt-seconds, about 10^{21} fission. This is about 100 times as much as in previous reactor transient experiments.

LEM Engine Decision Due Soon

A decision is expected withi eight to ten weeks in the competition to develop the variable-thrus lunar descent engine for the Luna Excursion Module.

Both contractors, the Rocketdyn Div. of North American Aviation Inc., and TRW's Space Technolog Laboratories are nearing completio of work accomplished under the parallel contracts. Insiders close to th LEM project say both engines an their respective throttling scheme show major promise and that th choice will be a very difficult one fo NASA; so difficult, in fact, that som observers speculate that an attemp may be made to continue funding th loser (though not with LEM funds as an advanced R&D project for possible use in other programs.

A status report on progress in th LEM development effort was presented last week at the four-da meeting of the New York Academy Sciences.

LEM project engineer Thomas Kelly reported that all the LEM engine systems have demonstrated fu mission capabilities thus far under altitude environment conditions and that important "fire in the hole" tests made at the Air Force's Arnold Engineering Center also showed that the ascent stage could be fired without difficulty while resting in its position directly above the LEM descent stage (M/R, July 15, 1963, p. 26).

A minor milestone in the engine check-out program is slated for next month at the White Sands Missile Range where the ascent engine will be fired for the first time in the new LEM engine test facility. The facility includes two altitude chambers and one sea-level test cell. The firing will be in an altitude chamber.

Shots of the Week

A "mother-daughter" payload launched by NASA from Wallops Island, Va., Jan. 13 failed to separate as planned. The 99-lb. package launched by an *Argo-D-4* rocket, was to have separated into two sections at an altitude of 170 mi. The two probes were to have exchanged radio signals as they rose to some 600 mi. and the exchange was to have been monitored and analyzed by scientists on the ground. Project engineer Ralph D. Welsh said that despite the separation failure "good telemetry signals were received and good ionospheric soundings were obtained." Telemetry data was being studied to determine the cause of the malfunction.

- The Communist New China News Agency has reported that Indonesia on Jan. 5 launched a two-stage scientific rocket from a location in western Java.
- The Navy opened its 1965 missile firing schedule Jan. 11 with the launch of a *Polaris A-3* from the nuclear submarine Von Steuben off the coast of Florida.
- The Soviet Union on Jan. 11 launched *Cosmos 52*, the latest in a series of scientific satellites aimed at carrying out the space exploration program announced by the USSR on March 16, 1962.
- An Air Force crew successfully launched an *Atlas* missile Jan. 12 from Vandenberg AFB, Calif.
- NASA test pilot Milton Thompson flew the X-15 rocket plane Jan. 3 in a test to gain data on air friction on the craft's surface.

Security Directive Changed

The Dept. of Defense has issued a directive on security classification effective Dec. 31, 1964, that reduces by about one-half the number of officers authorized to place secret and top secret classifications on documents.

Some 300-400 senior officers have had such authority in the past.

The directive, which also aims at stopping the delegation of such authority to middle-ranking officers, was issued by the office of Deputy Secretary of Defense (Security Policy) Walter T. Skallerup, Jr.

Arkansas Gets Comsat Facility

A ground station for research communications with synchronous satellites will be constructed in Arkansas by Hughes Aircraft Co., according to plans announced last week.

The facility, which includes an 85-ft. antenna and supporting buildings, is expected to be operational in about a year, Hughes spokesmen said. The firm estimates that cost of construction will be considerably less than current estimates for ground stations, which run to about $20 million.

The firm plans to seek Federal Communications Commission approval for construction and experimental operation of the station in the near future.

The Arkansas location—near the University of Arkansas at Fayetteville—was chosen because of its potential visibility of both Pacific and Atlantic Ocean satellites, suitable antenna angles, lack of electrical interference and variable weather.

Comsat Deadline Extended

The Federal Communications Commission has extended until Jan. 25 the deadline for replies to comments on the communications satellite ground station control issue. The one-week extension was requested by the Communications Satellite Corp.

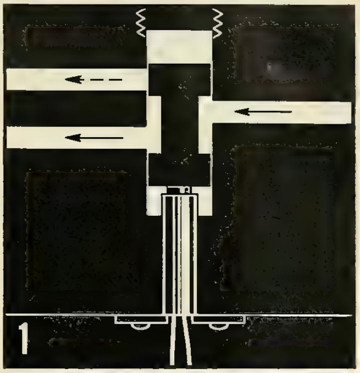
Meanwhile, Comsat issued RFP's to nine foreign companies for studies of launch vehicles for a medium-altitude communications satellite system. Sixteen U.S. firms were petitioned for such studies last month. Deadline for proposals has been reset for Feb. 1.

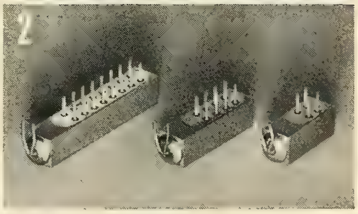
Planning Sessions Set

First in the rescheduled series of advanced planning briefings for industry has been set for Mar. 3-4 in Los Angeles. Sponsored by the Defense Dept. and the National Security Industrial Assn., the program will continue with sessions in New York City, Chicago, Dallas and Washington, D.C., during March and April.

2 IDEAS ON RELIABILITY

with Atlas explosive-actuated devices





1 Consider piston actuators. In redundant circuits, reliability soars to .9999 at a 95% confidence level. Often used to operate a valve (as in spool valve illustrated), activate a latch or move a mechanical load, or as a locking or releasing device.

2 Atlas miniature switches were designed to meet stringent reliability requirements in rugged environments. Example: when switch is initiated, contacts are jammed home and almost fused together—no possibility of contact flutter or bounce. Compact and lightweight, they are available with 1 amp, 1 watt, no-fire characteristics . . . RF protection . . . delay timings.

These are just two ideas of many. Send for complete technical literature on a variety of Atlas explosive switches, actuators and specialty components and systems.

ATLAS
CHEMICAL INDUSTRIES, INC.
Aerospace Components Division
Valley Forge, Pa. 19481

Circle No. 6 on Subscriber Service Card

TORTURE CHAMBER

In a huge laboratory building in Huntington Beach, California, 60 foot high rocket stages like this one are undergoing twisting strains and searing heat even more severe than what they will meet during actual missions. They are being tortured beyond endurance on earth to make sure of perfect performance in outer space.

This structures laboratory is only one of 11 buildings in the Douglas Space Systems Center, which is very probably the most advanced company-owned space complex in the world. It incorporates the finest and most modern equipment including a space simulation chamber 39 feet in diameter capable of housing a complete manned spacecraft.

Here, Douglas is building the S-IVB, the *Saturn* stage which will power three *Apollo* astronauts from earth orbit to moon orbit. Also being developed are manned orbiting space laboratory designs, and work is progressing on other orbiting and planetary programs relating to the advancement of U.S. space supremacy.

DOUGLAS

MISSILE & SPACE SYSTEMS DIVISION

ARPA 'intrigued' . . .

New A-ICBM City Defense Studied

Low-cost system would protect against small number of missiles, not all-out assault; agency stressing terminal-phase intercept

by Michael Getler

NEW YORK—The Dept. of Defense is now actively studying the feasibility of developing a relatively low-cost and less sophisticated anti-missile system for city defense.

The system would not be effective against the massive nuclear onslaught of another major nuclear power but would provide protection against a so-called nuclear "mistake" involving only one or a few missiles, or a poorly coordinated attack, or an attempt by a smaller nation to inflict some kind of nuclear damage on the United States.

The possibility of such a system was termed "intriguing" by Charles M. Herzfeld, deputy director of DOD's Advanced Research Projects Agency (ARPA). He would not elaborate on the concept, but told M/R that such a system is "in study now," that it was "an interesting question," and that it was "being looked at very carefully."

The small-country or "Nth country problem" was investigated as part of the *Nike-X* threat analysis study just completed (M/R, Jan. 4, p. 12).

Herzfeld, discussing the questions of ICBM and satellite defense and penetration aid devices at the sparsely attended four-day meeting of the New York Academy of Sciences here last week, also said that the so-called "hardpoint" concept of anti-missile defense for small-area military targets, such as a ballistic missile silo, "might become an attractive option in time."

He explained that this could come about if the U.S. were ever to reach some form of arms control agreement which limited the number of ICBM's. "There may be an advantage then to increasing the number of ICBM's which could be made to survive an attack (by putting in A-ICBM's) without adding ICBM's."

Regarding the ICBM and A-ICBM position of the U.S. vis-a-vis that of the USSR, Herzfeld said he was "quite confident that our own confusion devices can confound any enemy defense, and that we can easily build enough missiles to overcome any enemy defense."

"The most serious danger," Herzfeld stressed, "is that another country might build a defense which its leaders think is better than it is."

● **Money no object**—Herzfeld pointed to the very large scale of expenditures and test effort that has gone into A-ICBM and penetration aid study and hardware effort, and that must be continued to maintain national security.

The *Nike-X* program this year accounted for about $300 million, he reported, and another $120 million was pumped into the area this year through ARPA's Project Defender, which "complements and also looks beyond the Army's *Nike-X* program." About half of the ARPA funds reportedly were spent on improving the ability to discriminate between warheads and decoys.

Herzfeld estimated that about $2-2.5 billion has been spent to date on ballistic missile defense in this country, "which has put us in the position of knowing what this is all about."

"This country," he added, "has spent so much on defense that I cannot think of a single experiment that was not done for lack of money, and I'm willing to take on all comers."

In addition, the Air Force and Navy programs on penetration aid development are roughly comparable in fiscal size to the missile defense efforts, he said.

The total spending is probably the largest single portion of the R&D budgets, he estimated.

● **Culling out**—Herzfeld said ARPA is placing most emphasis on terminal-phase defense (where the intercept is conducted on the order of tens of miles from the target) against ballistic missiles, using atmospheric sorting, as the only one that appears at all feasible.

Of the systems that would have attempted intercept shortly after ICBM launching, Herzfeld said that the *BAMBI* satellite program was the only one ever seriously considered, but that it is now "quite dead," because of expense and low reliability. Herzfeld estimated it would have cost tens of billions of dollars per year to keep it operational.

Regarding the mid-course intercept phase (where the missile is in free-fall, coasting at an apogee of about 500-600 miles) Herzfeld said "no feasible defense system had been developed." He pointed out that it is much too easy for the offense to build cheap decoys and deploy them during this phase. He noted, however, that for ground-based satellite interception, where there is time to precisely observe orbital positioning on successive passes, it is easier to discriminate (M/R, Oct. 28, p. 19). He further noted, at this point, that the U.S. has two operational anti-satellite systems (M/R, May 11, p. 12).

Herzfeld said it was ARPA's view that both conventional and nuclear warheads for A-ICBM's should "be looked at." He mentioned the radar-blackout problems associated with the use of nuclear devices, and the very difficult interceptor guidance problems associated with the conventional explosives. Seeking to correct a popular misconception, he declared that nuclear A-ICBM warheads would not produce any danger to cities they ring.

● **To be resolved**—Regarding the broad question of whether A-ICBM deployment makes sense, Herzfeld said the answer "is just not obvious."

"It is still true," he pointed out, "that it does not appear possible to build a good defense system for a city that a determined attacker couldn't enter. It would just raise the entry price. It would take a quantity of missiles that is within reach of a major power."

"If you buy a system for cities," Herzfeld says, "then the question is which cities and how many. The point here is to make these previously interesting targets as unattractive as those which are normally unattractive—and therefore to deny the enemy a unique best-attack option."

Herzfeld also noted that a city defense should involve an extensive fallout shelter program, since without one an enemy could "shoot upwind of a target using a ground burst and prevailing winds to kill a population."

The hardpoint defense of military targets, Herzfeld said, is quite a different problem; an inferior defense system might be useful since "loss of a few missiles doesn't matter much." ■

Working since last July . . .

DOD Declares Transit Operational

Three-satellite system was used successfully by Task Force One during its recent Sea Orbit cruise around the world

TRANSIT—The Navy's navigational satellite system—has been declared operational. In making the announcement, the Defense Department said the system had been in operation since July, 1964, and that it had been used "extensively" by the nuclear-powered Task Force One on its Sea Orbit voyage around the world in August and September.

Three satellites are providing operational fleet units with "an accurate, dependable, world-wide, all-weather, 24-hour-a-day, passive navigational fix capability on a world-wide basis," says Capt. F. H. Price, Jr., commanding officer of the nuclear-powered cruiser USS Long Beach on the Sea Orbit mission.

Gravity-gradient-stabilized, the *Transit* satellites weigh between 110-160 lbs. and are launched into near-circular 600-mi. polar orbits from the Navy's launch facilities at Pt. Mugu, Calif. The booster used to launch *Transit* is the *Thor-Able Star*. Normal practice is to use the excess payload capacity of the *Able Star* to launch several other satellites along with *Transit*.

- **How it works**—Navigational fixes—accurate to 0.1 mile—are obtained from *Transit* by computing the relative position of the tracking station with respect to the path of the orbiting satellite. This computation is made by measuring the doppler shift in radio frequency signals transmitted from the satellite.

From this information, plus the orbital parameters, the longitude and latitude of the ship can be determined.

Operated by the U.S. Navy Astronautics Group at Pt. Mugu, the system consists of five groups of equipment: the satellites; the tracking stations—located at Mugu, Hawaii, Minnesota and Maine—to measure and record the doppler shifts from the passing satellites; the computer center to calculate orbital parameters of the satellites and to transmit the data to an injection station; the injection station to transmit the orbital data to the satellite; and the shipboard navigation equipment to automatically receive and record the doppler shift of the satellite frequencies and the orbital parameters.

The shipboard equipment is estimated to cost about $12,000 per copy on a production basis. Fully automatic, it activates itself when the satellite approaches, receives the data, computes the fix and types the result to the navigator. An airborne counterpart of the terminal is under consideration by the Defense Department.

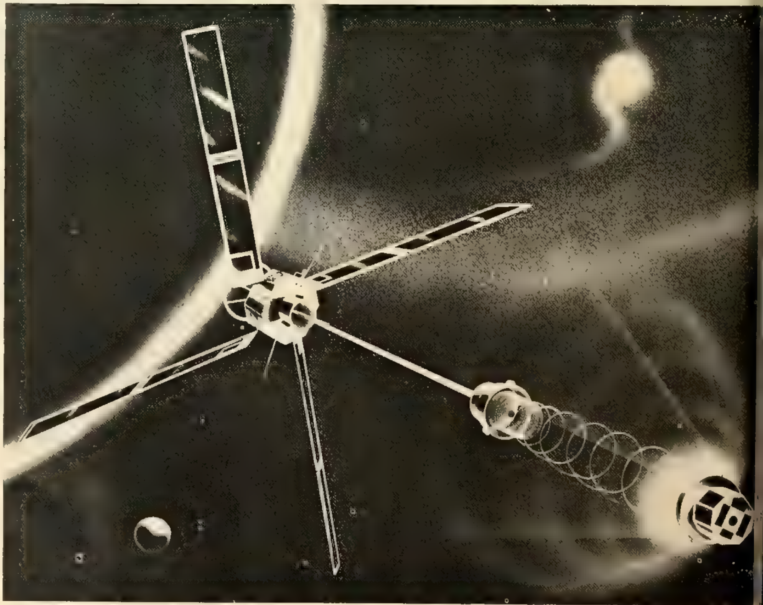
Transit was developed for the Navy by the Applied Physics Laboratory of Johns Hopkins University, Baltimore. APL also built the developmental models that have been launched over the past three years. In December, 1964, however, the first production model was built by the U.S. Naval Avionics Group in Indianapolis, Ind.

- **Capabilities**—The satellite is presently designed to have a lifetime of two years. It contains an ultra-stable (deviation of 1 part in 10 billion) oscillator for generating time markers, and two stable harmonic radio frequencies. A completely transistorized memory unit is used to store orbital parameters. All circuits are welded or wire-wrapped to insure greater reliability and to reduce weight and volume. One of the operational satellites is nuclear-powered; the other two rely on their 18,000 solar cells to provide power to the satellite.

Additional SNAP-9A units have been delivered to the Navy by the Atomic Energy Commission for use in *Transit*. Last April 21, however, a *Transit* satellite failed to go into orbit and burned up in the atmosphere. The Plutonium-238 fuel burned up during re-entry, but the sub-micron-size particles are expected to fall over the Earth for several years.

NASA is determining commercial applications of a navigational satellite system and may undertake to develop its own system if it is economically feasible. ■

NAVY'S TRANSIT 5-A prototype operational satellite in orbit 600 mi. above Earth



Polaris singled out . . .

U. S. Destructive Power Underscored

Discretion to tell potential adversary of strategic force capabilities held essential to arsenal's effectiveness

POLARIS—the backbone of the U.S. assured destruction force—has been designed not only to have dependable capabilities for adequate destructiveness but also to enable these capabilities to be fully understood by other nuclear powers.

"Should our national leadership determine that respect for its inescapable destructive capability is reducing in the minds of the national leadership of other nuclear powers," R. Adm. Levering Smith, technical director of the *Polaris* project, told a New York audience, "more can be disclosed and demonstrated without thereby reducing its [the strategic force's] effectiveness."

The ability to so advise an enemy of the capabilities of U.S. deterrent weapons without degrading their capabilities is an essential element of the effectiveness of these weapons, Adm. Smith said in the Jan. 12 speech to the New York Academy of Sciences Conference on Civilian and Military Uses of Aerospace.

- **Survivability stressed**—The very characteristics of strategic weapons—destructive power six orders of magnitude greater than that carried by the largest bomb load of a World War II bomber and the measurement of delivery time in minutes rather than hours —"present national leadership a natural temptation to conclude that a decisive advantage can be gained in a few minutes or hours by a surprise attack."

To ensure that such reasoning does not gain prevalence, it is important that the continuous effectiveness of the system as well as the continuing survivability of retaliatory weapons be capable of demonstration.

Although the level of assured destruction capability that would deter political actions by an enemy is a political decision, it provides the basis for a military determination of the number of units to be produced and deployed. It does not, however, provide guidance for the design of these units.

In the *Polaris* system, according to Adm. Smith, "this dependable capability to inflict unacceptable damage, which cannot be decisively reduced by surprise attack, rests upon use of quiet nuclear submarines which are most difficult and costly to detect and destroy simultaneously in decisive numbers; upon a command and control communication system which is difficult and costly to destroy or to interfere with adequate message reception for a decisive period of time. . . ."

- **Second-strike insurance**—Other factors contributing to this dependable second-strike power are a missile "of sufficient accuracy and warhead power to assure that a single warhead penetrating active defenses will cause major destruction to urban industrial centers or that a very small number of warheads will destroy a hardened point military target," and a re-entry system with such characteristics as to make it very much more costly for an active defense system to destroy a warhead than it is for a submarine to target a warhead.

Destruction of support facilities—tenders, supply ships and shore-based installations—could not defeat the *Polaris* system, Smith asserted.

With two-thirds of the force on patrol at any one time and provisioned for three-month operations, these submarines could continue to function and fulfill their mission for at least one month after the initial destruction of support facilities.

- **Overcoming the elements**—System effectiveness is also enhanced by removing restrictions of weather or sea state that normally might be imposed on missile launching. If these natural conditions limited the launch capability, an enemy's ability to defeat, at least partially, a *Polaris* system would be enhanced to a "predictable degree."

This temptation to surprise attack has been reduced, Smith said, by designing the launching and ship-control systems to permit launching "in all conditions of weather and all but such infrequent high sea states that only a very small fraction of the force would be prevented from launching at any one time in the worst period of the year."

A dependable command and control system, one that does not compromise the location of the submarine, is essential so that the system be responsive to the control of national leadership. ■

Navy Satellite Charts Solar Activity

RADIATION from the Sun was at a minimum during May, June and July, 1964. During that period, a Navy radiation-monitoring satellite recorded no hard X-ray emanations. In August, however, the satellite data shows that all types of X-rays once again began to stream from the Sun.

The measurements were taken by a satellite—dubbed *Solrad*—launched into orbit more than a year ago. Under the sponsorship of the Naval Research Laboratory, *Solrad* is part of the continuing effort to observe the Sun during the period of minimum activity in its 11-year cycle. This program is tied in with the International Years of the Quiet Sun.

NRL scientists also reported that the 11-year solar cycle appears to be part of a longer, 80-year cycle. Also, there is some evidence, they reported, for an even longer solar cycle of 400 years.

Solrad also provided information on the nature of the Sun's corona, which generates the hard X-rays. Rather than a homogenous region, the satellite data suggests that the X-ray region of the corona is a series of small cells that flare up, spewing forth hard X-rays, and then decay rapidly. However, viewing this phenomenon from Earth, these small cells appear to merge and give an appearence of homogeneity.

New York meeting told . . .

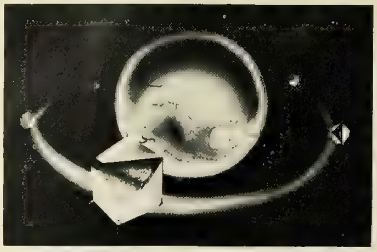
DOD's Comsat Will Be Very Rugged

Satellites being developed by Philco will have 3-year lifetime and 1½-year MTTF; advanced system may be implemented in 1968-70

NEW DETAILS on design of DOD's initial communication satellite program (M/R, July 20, p. 10) reveal evolution of a low-capacity but highly serviceable system for filling survivable, long-range defense communications needs in the 1966-68 time period.

The system, slated to be deployed in about 13 months, was described at the New York Academy of Sciences meeting here last week (see p. 13) by Jay J. Cohen, technical advisor on the comsat project within the Defense Communications Agency (DCA).

The satellites, now under development for the Air Force by Philco, will be launched into a near-synchronous equatorial orbit—18,300 n. mi.—from the Eastern Test Range, using the *Titan III-C*. Each launch vehicle will carry eight satellites, except in two launchings in which seven satellites will be carried, in addition to a gravity-gradient stabilization system experiment. Small 5-10-fps relative differential velocities imparted by a cold-gas retro-thrust system will be set up in orbit to disperse the satellites around the Earth, with a complete system dispersed in less than 100 days.



ARTIST'S CONCEPT of Philco's comsat.

The satellites will be spin-stabilized, will operate in the 8-Gc-up, 7-Gc-down frequency band, will have an RF power output of 2.5 watts using a traveling wave tube, and will have antenna beam-widths of about 25 degrees.

Satellites will be designed for a three-year lifetime, with one and a half years as the minimum specified mean-time-to-failure. No command and control signals are required, according to Cohen.

With proper deployment, virtually complete global coverage will be achieved with 20 satellites.

- **Flexibility**—System capacity is dependent upon ground terminals. Two 40-ft. dish terminals will yield two high-quality voice channels, with greater capacity at reduced quality. With digital data terminal equipment, up to 16 duplex secure vocoded voice channels can be provided. There is also capability for voice, vocoded voice, and many duplex telegraph channels with smaller antennas such as the 15-ft. types now used in Vietnam or the 6-ft. dishes used as Navy shipboard equipment.

DCA also has initiated studies for an advanced comsat system which it hopes to implement in the 1968-70 time period, and Cohen says that a recommendation may be forthcoming by the end of the year on what type of system this should be. ■

Missile Funds Down, RDT&E Up in FY '66 Budget Request

MISSILE PROCUREMENT in the Fiscal Year 1966 budget will drop $1.2 billion from the current spending figure of $2.626 billion—reflecting completion of the major scheduled buys of strategic retaliatory weapons. Biggest drop is in Air Force missile procurement—$933.9 million below the FY '65 appropriation.

New obligational authority for research, development, test and evaluation (RDT&E) will increase in the budget, which will be presented to Congress Jan. 25. However, the increase reflects more a "housekeeping" or overhead increase than any new RDT&E efforts. Spending for research and development in FY '66 will be $6.5588 billion—an increase of $235.3 million over the amount appropriated in FY '65.

- **Missile drop-off**—In the procurement of missiles, the Army will request $253.7 million in FY '66. In the current spending year, it asked for $282.6 million and Congress appropriated $233.9 million. The $19.8-million increase represents another attempt by the Army to convince Congress to allow it to produce the *Redeye*, which was cut out of last year's request.

Navy missile procurement will be halved—dropping from the $660.1 million requested and appropriated in FY '65 to $364.0 million in the new budget. Primarily, this results from substantial prior-year buys of *Polaris* missiles and a continuation of the *Polaris A-3* retrofit program.

Marine Corps missile request will be $13.0 million. Last year the Marines asked for $13.1 million and received $2.6 million. Again, as with the Army, the $10.5-million increase reflects a desire to put *Redeye* into production.

Air Force request for missiles will be $796.1 million. Both the request and the appropriation for FY '65 totalled out at $1.730 billion. The biggest reduction, this reflects the large prior-year buys of *Minutemen* and the Administration decision to limit the land-based ICBM force to 1,054 missiles.

Total procurement requests for missiles in the Defense budget will be $1.4268 billion. Requests for missiles in the current fiscal year were $2.686 billion and the appropriations totalled $2.6266 billion.

In RDT&E all of the services and the Defense Agencies receive what appear to be cost-of-living increases. The Army will request $1.438 billion, an increase of $98 million over the $1.340 billion appropriated for FY '65. The Navy request will be $1.473 billion, an increase of $99.9 million over the $1.373 billion appropriated for FY '65.

Air Force RDT&E spending will be only $35.8 million larger than the current fiscal year appropriation of $3.112 billion. The Air Force will seek $3.1478 billion for FY '66. Defense Agencies will request $500.4 million, an increase of $2.4 million over FY '65 appropriations.

These figures have been obtained from unofficial sources and could vary slightly in the final budget. ■

In declining market . . .

Prescription for Stability Proposed

A. D. Little report recommends mixed strategies for coping with problem; predicts continued increase in some areas of R&D

NEW YORK—Within the next five years, the aerospace industry's share of production money in the defense budget will decline about 30%, and defense research, development, testing and evaluation (RDT&E) will decline about 15%, according to a just-released report prepared by Arthur D. Little, Inc.

The study, entitled "Strategies for Survival in the Aerospace Industry," adds that while the NASA budget may increase by about 10% within the five-year period, the overall aerospace market will face about a 15% decline.

The report, which ADL President James M. Gavin says "reflects our current view of the prospects of the industry," was funded in-house by the Cambridge, Mass., firm. It is now being circulated primarily to top industry and government officials.

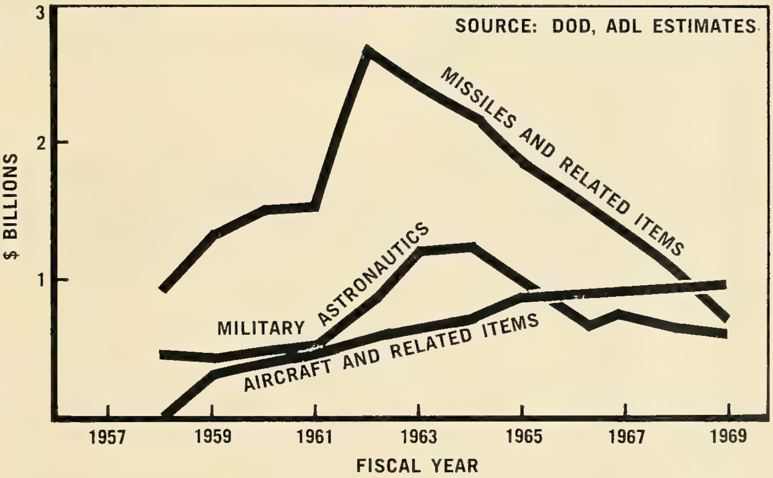
"The aerospace industry clearly is no longer a growth industry," the report states. "Aerospace companies must therefore accept the fact that they cannot reasonably expect to grow for the remainder of this decade. Their problem is not to stimulate growth but to achieve stability."

The author of the report, Thomas G. Miller, Jr., says that while aerospace industry sales showed a remarkably steady growth in the 1954-63 period, "many participants perhaps forgot that there were concrete, finite objectives to be achieved with these funds."

The question now of major concern to the industry, according to Miller, is not whether or when defense procurement will be reduced—these questions, he says, have been answered reasonably well by Secretary of Defense Robert S. McNamara and his principal assistants—but "rather what the size and nature of the reduction will be. Thus far," he reports, "the answers have been less than precise, perhaps because the Dept. of Defense itself does not know exactly the extent to which it can reduce its budget."

• **By categories**—However, Miller says in his study that "on the basis of the estimated rates of buy-out of the *Minutemen* and *Polaris* programs (the two primary projects in the category of strategic retaliatory forces, the area from which the major spending reductions will come) and the known levels and forecast changes in other programs, one can forecast roughly that the decline in missile procurement will go from about $2.98 billion in Fiscal Year 1965 to $1.23 billion in 1969." (See chart.)

The level of aircraft procurement, $6.3 billion in FY '65, will decline much less precipitously, in Miller's view, averaging about $6 billion annually through FY '69.



Changes in the structure of DOD R&D authorization.

DOD R&D funds available should drop about $1 billion during the FY '66-69 period, he estimates, but RDT&E in areas other than strategic systems will probably remain at current levels, possibly increasing slightly.

The portion of the NASA budget available to industry should grow from $4.38 billion in FY '65 to just above $4.8 billion by FY '69, he estimates, and thus "will still constitute a modest growth market for the remainder of the decade."

• **R&D ascendant**—One major impact of NASA on the nature of the industry's total business has been in altering the ratio of R&D to procurement. In FY '63, for the first time, the level of R&D business exceeded the level of production business (virtually the entire NASA budget is viewed as R&D). "It appears that the increase in the relative importance of R&D (in both NASA and DOD) will continue and that it will be 60% greater than aircraft and missile funding by the end of the decade."

The ADL report stresses that this decline in production and relative increase in R&D is the single most important trend in the aerospace market. "Many companies have not yet fully realized the implications," Miller says.

He adds that "far more important than the decline in the absolute level of DOD procurement dollars is the decrease in the number of major program opportunities and the change in the nature of the programs becoming available."

During the first five years of the ballistic missile program, Miller reports, "the average number of new production programs each year was four or five. Since FY '60, the average number has been one a year."

The industry obviously would also be affected by an arms control agreement with the Soviets, but Miller feels that no such agreement is likely in the near future and that concern over this possibility, or further reductions in force levels, is probably premature. "The industry probably has considerable time to plan for the possibility of an eventual major reduction in the need for its products. But it has less time to adapt to the changes in its market structure."

Having set this not-too-pleasant economic stage, the report also cites recent statements by top DOD officials clearly indicating that while the government recognizes the major problems facing the industry, it believes that the industry must work out the solution and that the survival of each company is up to the company itself.

Then the report charts some "Strategies for Corporate Survival."

● **Avenues**—Miller points out that industry and government spokesmen in recent months have discussed three strategies for individual aerospace companies faced with at least the temporary end of a growth market: 1) diversification into other sectors of the aerospace market; 2) diversification into broad problem areas (e.g., mass urban transport, advanced power systems) appropriate for the application of technical skills on the scale of those available in aerospace; and 3) diversification into non-aerospace commercial or industrial products.

The first of these, Miller says, "is inappropriate, because the industry is already so overdiversified that there is significant overcapacity in every technical area."

The second prospective strategy has received considerable attention recently in the light of some announced Administration goals to improve conditions domestically and some action by state governments to solve perplexing local problems. Miller says it is desirable but not feasible, unless government funds are committed to the creation of markets. He feels that aerospace firms should take advantage of opportunities to participate in such projects, but he points out that "funded studies are not the same as a market for systems engineering or hardware."

Discussing this further with MISSILES AND ROCKETS, Miller said he was not optimistic that any of these talked-about improvement programs—with the possible exception of those connected with the ocean sciences and desalination—will get into a substantial hardware effort within the next five years.

The industry itself, says Miller, does not enjoy profit margins adequate to justify the large scale and long-term support required by some of these speculative ventures.

The third approach—turning to other types of production—has been attempted by many firms, in most cases unsuccessfully, says Miller, because of inexperience in non-aerospace affairs. "Those who have successfully diversified have done so by acquisition."

While diversification to broaden a firm's financial base, marketing, and management capabilities is sound strategy, Miller says, "unfortunately it is not the solution to the problems of all companies in the aerospace business."

● **Plus adaptation**—For a more immediately appropriate mix of strategies, Miller suggests that individual firms diversify through carefully selected acquisitions outside the aerospace market—and then establish programs of "adaptation" and "specialization."

ESTIMATED LEVEL OF MISSILE PROCUREMENT

Fiscal Year	Billions of Dollars
1963	3.97
1964	3.71
1965	2.98
1966	2.53
1967	1.70
1968	1.38
1969	1.23

SOURCE: ADL estimates

By adaptation, Miller means greater adjustment to a broader R&D business base rather than a predominantly production orientation. This strategy has been employed by a number of companies, which, recognizing the importance of new technology, have been willing to invest steadily and significantly in internal R&D, have established corporate basic research activities, and have had productive research groups. The pay-off has been substantial for these firms, with the result that more than 50% of DOD and NASA R&D contracts in recent years have been concentrated in fewer than 10 major firms.

For some companies, Miller says, "it is perhaps too late to expect to be complete masters of their future during the next five years; for others, with more favorable backlogs, there is time to effect a more orderly transition."

Despite the trend to more R&D *vis-a-vis* production, Miller notes that experience has shown that government-sponsored R&D produces little or no profit. He points out, however, that most of the testimony concerning low profitability comes from the aerospace and electronics industries that have been oriented toward volume production.

● **STL's example**—Miller invokes the experience of the TRW Space Technology Laboratories as indicative of the fact that, when an aerospace R&D company is appropriately organized and managed, it is possible to operate at a profit.

Miller cites STL's role in the *Nuclear Detection Satellite* program under an incentive-type contract wherein the firm earned 93% of the maximum allowable fee based on the performance of the first two satellites.

The company, says Miller, looks upon this as the start of a trend favoring the highly competent specialist at the expense of marginal performers who will be driven out of the R&D business because of its low profitability for them.

Though "adaptation" is the prerequisite for survival, Miller stresses that very few companies can acquire the broad capabilities already possessed by the large companies. "Survival in a static but highly competitive market, therefore, also requires that all but the largest companies adopt a complementary strategy of 'specialization'; that is, concentration of the management, technical, and marketing efforts of each company in a relatively few product areas where past performance, existing capability, and future customer requirements suggest the greatest possibility of success."

● **Two flaws**—Miller also says that two weaknesses in the industry will require increased attention. First, he says that unless the industry adopts programs to acquire different kinds of management capabilities, attempts to convert major portions of companies to other kinds of activities probably will fail. Second, many companies are deficient in long-range planning and the market forecasts upon which they are based. "Part of this problem stems from the difficulty of analyzing the complex interactions between the elements of a company and between a company and its market," he states.

These reported weaknesses in the industry contrast with the basic income-producing strengths of A. D. Little, Inc., reportedly one of the largest technical and management research consulting firms in the world.

The ADL report released last week is the second in a series relating to the aerospace industry. The first report, entitled "How Sick is the Defense Industry?", was published in 1963. Response was "so favorable in terms of assignments from companies and involvement in a number of things," Miller told M/R, "that we decided to continue a series of examinations of various aspects of the defense industry."

In about 6-12 months, ADL is expected to report upon the way industry has fared under the McNamara administration. ■

Technical Countdown

ELECTRONICS

Greatly Improved TWT Revealed

A traveling wave tube with a 40% efficiency constant at any output from 5 to 20 watts has been developed by RCA's Electronic Components and Devices Div. The ceramic-metal TWT operates at 4 gc, and was designed for a 50,000-hr. operating life, developers claim. Twelve inches long, the 25-oz. device uses a periodic permanent-magnet focusing system, a single-stage collector, and is conduction cooled. An improved version of the TWT developed by RCA for *Relay* satellites, the tube will be capable of operation during launch. The efficiency gain over the earlier TWT's is nearly double, the firm disclosed.

New Scanning Device in Development

Scientists at Cornell Aeronautical Lab., Inc., are building a prototype model of a birefringent scanner. The device requires no vacuum tubes yet forms an image resembling a normal TV picture. The principle on which the scanner, called BISCAN, is based is the rotation effect, or double refraction, of polarized light when it is subjected to a stress while passing through a glass or silica plate. Two silica plates, each handling light polarized at right angles, together with an image intensifier and electronic equipment comprise the major components of the system. The lack of vacuum tubes means an increased ability to withstand higher environmental stresses. The device could serve as a display unit, but it can also function as a camera. Other applications include computer memory storage and optical correlation. The prototype development is being carried out under a $71,000 contract with NASA's Ames Research Center.

PROPULSION

3-Axis Control Ion Engine in Development

A lightweight ion propulsion system for providing three-axis attitude and station keeping control of heavyweight synchronous satellites is being built by Hughes Aircraft Co.'s Research Laboratories, Malibu, Calif. The system will weigh about 55 lbs., require only 150 watts of power, and according to George R. Brewer, manager of the Ion Propulsion Dept., could provide continuous station keeping and attitude control functions for a 1,000-lb. satellite up to a period of three years. The engine, designated the Mark II, and essentially a refinement of the Mark I laboratory prototype Hughes developed for NASA's Lewis Research Center, is a company funded effort and is not yet in the hardware stage. Consisting of twelve 0.3-millipound ion thrusters clustered in four groups of three, feed systems, engine control systems, power conditioning equipment and control and logic networks, the Mark II will provide the required directional thrust capability plus thrust for second order effects such as translational accelerations.

MATERIALS

Plum Brook Test Tank Under Contract

A cylindrical, aluminum space simulation chamber some 100 ft. in diameter and 122 ft. high will be erected at NASA's Lewis Research Center Space Propulsion Facility, Plum Brook, Ohio. The massive simulator will be built by Blount Brothers Corp. and Chicago Bridge and Iron Co. under a joint contract valued at $5.178 million. The facility will be used for evaluation and development testing of complete spacecraft as well as nuclear electric power generation and propulsion systems. Possible problems in space during start-up, power setting changes, long-term operation and shutdown will be studied. The facility is scheduled for operation early in 1967.

Explosives Encased by Electrodeposition

Small explosive charges can be encased with electrodeposited metals in almost any shape and thickness using a technique developed by scientists at the Naval Ordnance Lab., White Oak, Md. The lacquered explosive is placed behind a barricade while a remote-operated plating bath is raised around it. Simple dc power supplies provide currents ranging from 5 amps for large plating jobs to a few milliamps for small tasks. A conductive coating is painted over the lacquer before the plating operation, and as soon as a thin deposit of metal is formed over the paint, the current is carried by the plating itself. The process is being investigated as a means of sheathing deep-water charges, improving the cutting efficiency of flexible linear shaped charges at extreme stand-off and fabricating simple shaped charges for mild detonating fuze and metal-sheathed prima-cord.

Glass-Wound Deep Submergence Hull Complete

A 1,224-lb. ring-stiffened filament-wound pressure hull designed to withstand pressures at 30,000-ft. ocean depths is being delivered to the Navy's David Taylor Model Basin by the fabricator, H. I. Thompson Fiber Glass Co. The hull will be hydrostatically tested at the Basin. At mid-bay, the cylindrical shell is 2 in. thick, tapering to almost 3 in. at the end closure joint. HITCO filament-wound the shell and rings, using epoxy prepreg roving. End closures were void-free and laminated from oriented plies of 181 glass cloth using an epoxy resin matrix.

SPACE MEDICINE

Solar Distillery Under Development

A compact, collapsible solar still for the purification and desalination of water is under development at Melpar, Inc. The still will produce two pints of fresh water per day with a solar radiation input level of 1,500 Btu/sq. ft. daily. The unit will weigh about one pound and have a volume of 40 cu. inches. The still is being developed under funds from NASA's Manned Spacecraft Center as part of a sea survival kit for future space programs. The device will be made of inflatable plastic, and Melpar spokesmen predict a substantial commercial market.

Space Motion Simulator

An advanced frictionless platform for use in simulating motions in space has been developed by General Dynamics/Astronautics. Called an "air spring," the platform stands about 15 ft. high and is supported by four air-bearings, which create a cushion of air between themselves and the specially constructed floor. The assembly offers virtually frictionless pitch, yaw and roll through 360 degrees, plus unrestrained vertical and horizontal movements.

Off-the-Shelf MORL Packages Seen

No breakthroughs needed for telemetry, communications and data-handling subsystems; experiments under study

by Charles D. LaFond

TELEMETRY, communications, and data-handling subsystems for *MORL*, NASA's *Manned Orbital Research Laboratory*, may not only fall easily within current state of the art but could very nearly be off-the-shelf items.

The 12-subsystem configuration, contained in the Douglas Aircraft Co. Phase IIA *MORL* study submitted to NASA's Langley Research Center in December, was prepared for the firm under subcontract by IBM's Federal Systems Div. The system as recommended by IBM includes PCM/FM telemetry, tape recording, voice communications, data processing and computing, closed-circuit TV, tracking aids, digital command, rendezvous radar, and antennas plus supporting facsimile, microcard file and viewer, and a film projection/scanner device.

• **Contract status**—IBM began its *MORL* studies as a member of the Douglas team in 1963 with the Phase I initial system study. This was a three-month parallel effort, with The Boeing Co. directing the other program. The Douglas contract was valued at roughly $453,000; IBM's portion was some $200,000. Late in September, 1963, the Douglas team was selected by NASA to continue the *MORL* study.

Phase IIA, totaling $1.5 million—$550,000 of it going to IBM—called for a complete system design study ending in October, 1964.

Phase IIB, now in negotiation, is expected to total $1.4 million, with about $300,000 to IBM. This part of the program will require studies of equipment integration, module requirements, experiment integration, and a more complete determination of the experiments needed and/or considered feasible.

• **Douglas MORL**—The Douglas-proposed *MORL* calls for a 260-in. dia., tubular space station capable of operating in a low-Earth orbit for from 2-5 years and carrying up to 10 crewmen. The craft would be launched unmanned atop a *Saturn IB*. A logistics spacecraft, consisting of an *Apollo* Command Module and a modified Service Module, would also be launched by a *Saturn IB* and would carry crews and supplies.

The twelve major subsystems included in the IBM recommendations provide a flexible telemetry, communications, and automatic data-processing capability for the *MORL*. These, said Dr. Peter Castruccio, director of IBM's space programs, were selected to meet all presently anticipated *MORL* requirements including maximum performance, safety and growth potential plus minimum modifications to logistics spacecraft and supporting ground systems.

A key NASA requirement in the selection of subsystems has been for equipment and techniques that would require no scientific breakthroughs and a practical engineering development effort—in short, subsystems that are essentially "off-the-shelf," requiring only adaptation or enlargement of capabilities to meet *MORL* needs. This overall requirement has been met, Castruccio asserted.

• **PCM, FM telemetry systems**—*MORL* telemetry will employ two pulse code modulation (PCM) systems and one frequency modulation (FM) system.

The whole configuration will be capable of performing both time-division and frequency-division multiplexing, analog-to-digital conversion, plus all the data programming and formatting necessary for transmission to ground. The system also will be capable of receiving and de-multiplexing telemetered data at VHF FM/AM from crew spacesuits, the *MORL* centrifuge, and de-orbiting cargo modules.

A continuously operating PCM system will handle low-rate operational and experimental data at 2.4 kilo bits/sec. (kbps). The second PCM system will operate intermittently at 19.2 kbps for higher-rate experimental data. Data exceeding the rate capability of the PCM systems will be placed on FM subcarriers by an analog system providing one 2-kc and one 1-kc channel. Data for the PCM systems will be acquired through addressable multiplexers (time-shared with the data processing system).

MORL operational data, generated while the craft is transmitting to ground, will be sent in real time. When out of sight of ground stations, data will be stored on magnetic tape. During playback, low-rate PCM data are sent at 32 times record speed; the other PCM data are sent at four times record rate. The resulting bit rate on playback for both PCM systems is the same—76.8 kbps.

All telemetry data transmitted to ground will go via a single FM transmitter. Operating in the S-band (2.2 to 2.3 gc) with a 1-mc bandwidth, the 5-watt solid-state unit will be fed by a complex signal including one 76.8 kbps PCM signal and a five FM-subcarrier composite signal. The latter is comprised of a 640-bps command verification signal from the digital command system, a 2.4 kbps signal of real-time data from the low-rate PCM system, the 1- and 2-kc data channels, and the other 76.8 kbps PCM signal.

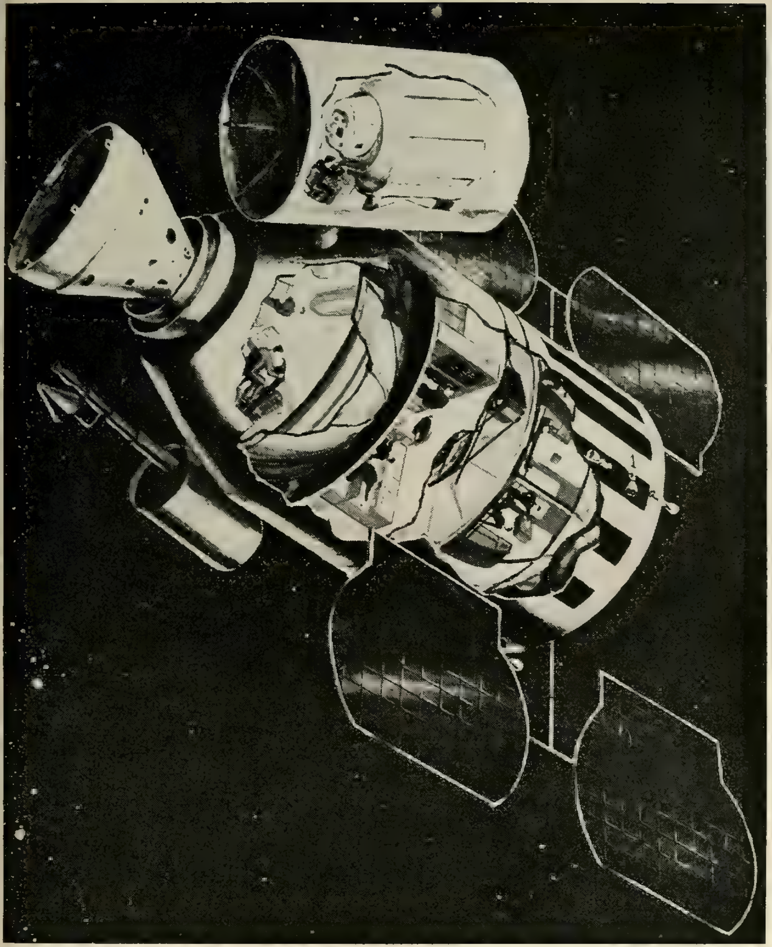
• **Tape recorders**—Three magnetic tape recorders will be required—two digital and one analog. The former employ 8-bit parallel recording on ½ in. tape. For analog data storage, the recorder uses two FM carrier tracks with a frequency response of from 0-2.1 kc each. Record speeds are 15/32 ips (for low-rate PCM) and 3.75 ips (for the medium-speed PCM); playback rate is 15 ips in either direction.

A 2,400-ft. type length provides 17.1 hrs. for recording low-rate PCM. (*MORL* occultation period will be about 16 hrs.)

The medium-rate PCM digital recorder will also be used to read or store auxiliary programs for the digital computer system.

• **Voice communications**—Two-way voice communications between the *MORL* and ground stations or the logistics vehicle will be handled by a pair of three-watt transceivers. These will employ low-noise preamplifiers and each will operate on either of two preselected VHF channels. A 20-w. amplifier for each transceiver will permit voice contact with specially equipped non-tracking ground stations.

An intercom system will provide



DOUGLAS MORL concept has compartmented vehicle (center) plus added sections such as bio-instrument module (top). Center compartment contains centrifuge.

communications with suited crewmen, the centrifuge area, and a docked cargo module.

- **ADP and computation**—Heart of the data-handling system will be the *Saturn V* digital computer now in development by IBM for NASA (M/R, Nov. 2, p. 31). Employing triple-modular redundancy, the system is a general-purpose serial machine with a random-access, magnetic-core memory. Two memory modules of 4,096 words (28 bits/word) will be used, but this could be readily expanded to use up to six more modules.

A data adapter, controlled by the computer, provides the interface between the computer and other *MORL* electronic subsystems. It includes the analog-to-digital and digital-to-analog converters, buffer registers and the electrical power supply for itself, the computer, and the data-acquisition subsystem.

- **Closed-circuit TV**—A highly flexible closed-circuit television system will provide on-board observation of *MORL* operational and experimental functions within and outside the vehicle and it will provide CCTV from space to ground monitors.

The on-board display will provide black-and-white pictures at 30 frames/sec., 525 scanning lines/frame, 500 elements/line, and 4:3 aspect ratio. Transmissions to ground will be provided for either a video signal at 15 frames/sec. or a 1-mc bandwidth analog signal from a film scanner.

Three identical TV cameras, three monitors, a patch panel, a sync generator, two pan and tilt mechanisms, three zoom lenses and a transmitter comprise the full system.

Five camera locations will permit full coverage of laboratory functions—three (stationary) inside at the operations control station, behavioral biomedical control station, and the centrifuge; two external points will employ remotely controlled gimballed instrument mounts providing a nearly complete spherical field of view.

A solid-state oscillator-modulator will be used to convert the TV 2.16-mc bandwidth video signal to a 10-mc signal at S-band. The same device can be driven with a 1-mc analog signal from a film projection/scanner.

Using a traveling wave tube, modulator output will be amplified to 20w.

- **Tracking aids**—A VHF acquisition-aid beacon/command transmitter and a C-band transponder will serve in two major roles—for tracking aid and for command transmissions.

When operated as a beacon, the first system provides a 2-w continuous-wave signal in the 225-260 mc range for orienting Teltrac, AGAVE or TLM-18 tracking antennas. The same system can be used as a command transmitter, using six discrete commands, to provide a backup for initiating cargo-module de-orbit.

The C-band transponder produces a peak output of 1,000w and is compatible with the large AN/FPQ-6, TPQ-18, FPS-16, and MSQ-26 ground radars.

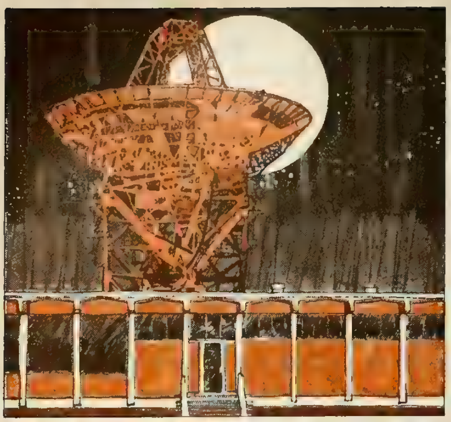
- **Digital command**—To receive commands from ground control stations, a digital dual command receiver will be provided for operation in the 406-450-mc range. Data, coded in five sub-bits/data bit, will be automatically analyzed for errors and then a command verification signal generated and telemetered to ground.

Commands, either discrete or digital messages, are interpreted by a decoder. Magnetic latching relays can be actuated by discrete commands; digital messages (at 5.7/sec.) are inserted into the computer through the data adapter.

- **Rendezvous radar**—An updated *Gemini/Agena*-type rendezvous radar will be included providing a maximum operating range of 500 n. mi. and a range accuracy of ± 15 ft. Operating at L-band in a pulsed, non-coherent mode, the system will employ interferometric techniques to obviate the need for antenna gimballing.

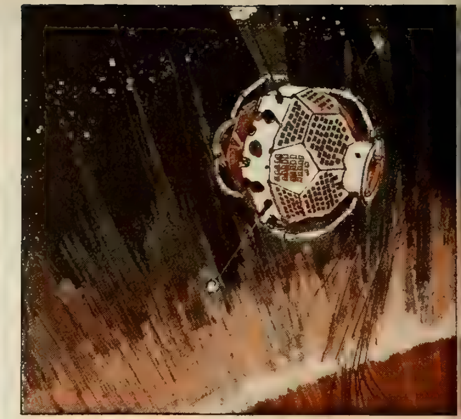
The *MORL* system will function with an interrogator aboard the logistic vehicle. For a backup mode, *MORL* will also be provided with a radar interrogator and the other vehicle will carry a transponder.

- **Other subsystems**—Four other subsystems round out the IBM study: (1) a facsimile capability using a typewriter will provide a readout of digital-command system data and can serve as an input device for the computer; (2) a microcard file and viewer for storage and display of maintenance and repair data; (3) a film projection/scanner device; and (4) VHF-UHF, S-band, and C-band antenna systems will be needed to support the on-board voice, acquisition-aid and command systems, television and telemetry systems, radar transponder, and the rendezvous radar and associated transponder. ■

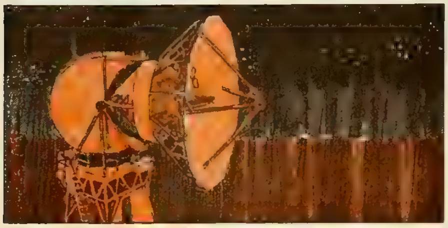


DEEP [illegible]

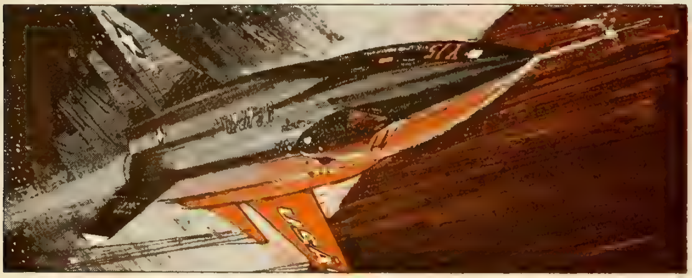
MERCURY (NASA)



[illegible]ENTIFIC SATELLITE INSTRUMENTATION (NASA, NAVY)



AP[illegible]



X-15 (NASA, AIR FORCE)

STATUS REPORT:

Space Communications

X-15 (NASA, Air Force)
North American — Prime
Collins — UHF communication, ADF

Mercury (NASA)
McDonnell — Prime
Collins—Communication systems manager. UHF and HF voice communication, command, telemetry, radar tracking, rescue beacon systems provided by Collins and subcontractors for all six Mercury flights. "Because of the excellent performance of these systems, some of their backup units were deleted." (NASA Mercury Project Summary SP-45).

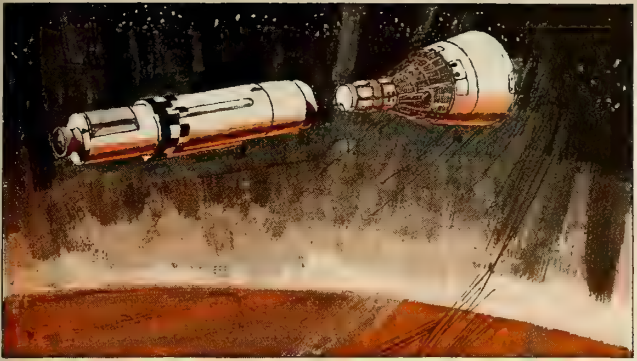
Gemini (NASA)
McDonnell — Prime
Collins — UHF and HF voice communication, astronaut intercom. First manned flight scheduled for early 1965.

Apollo Command (NASA)
North American — Prime
Collins — Systems management for VHF, HF, C Band and S Band communication, recovery beacon, audio center, premodulation processor, data storage, PCM telemetry and bench maintenance equipment. Manned earth orbital flights prior to lunar landing before 1970.

Apollo Lunar Excursion Module (LEM) (NASA)
Grumman — Prime
Collins (Subcontract to RCA) — Premodulation processor, audio center. First lunar landing late in this decade.

Collins Research Stations
Company stations near Cedar Rapids, Iowa, and Richardson, Texas, for space communication, tracking and radio astronomy. Cedar Rapids stations equipped with precision radio sextants, radio telescopes, space radars and two 28-foot dish antennas; Richardson with 60-foot and 28-foot parabolics. Pioneering solar and lunar radio astronomy, including first radio sextant (1948) and continuing radio meteorology. First communication between points on earth via moon (1951). First two-way radio voice and facsimile communication via artificial satellite, Echo I (1960). Successful transmission of signals from Dallas to Naval Research Laboratory in Maryland via Echo II, and additional Echo II bounces involving Stump Neck and Naval Electronics Laboratory, San Diego (1964).

Deep Space Instrumentation Facility (NASA)
Jet Propulsion Laboratory — Responsibility for stations and technical liaison of missions.

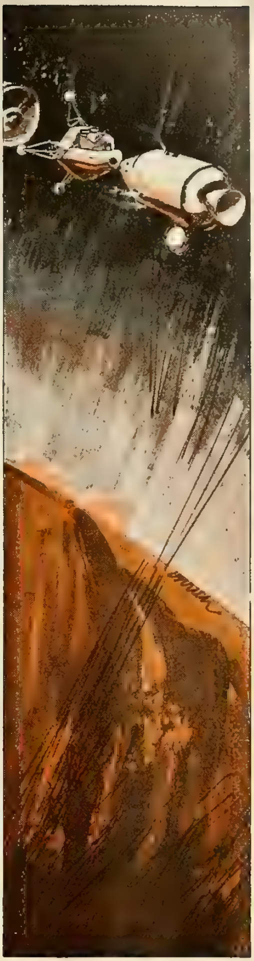


GEMINI (NASA)

COLLINS RESEARCH STATIONS

SATELLITE TRACKING & DATA ACQUISITION NETWORK (NASA)

MISSILE RANGES



APOLLO COMMAND (NASA)

Collins — Receiving site systems, including electronic equipment, antenna feeds, facilities, but excluding 85-foot antenna structures, at Goldstone, California; Woomera, Australia; and Johannesburg, South Africa. This network is involved in all major lunar and interplanetary probes and experiments.

Satellite Tracking and Data Acquisition Network (NASA)

Collins — Prime systems contractor. Collins will supply antenna control systems, receiving equipment, data recording systems and boresight systems. Stations in operation in Fairbanks, Alaska, and Rosman, North Carolina. Additional facilities will be operational in late 1965.

Ground Support

Eastern, Western Test Range

Collins — Microwave, HF single sideband, VHF and UHF communication ground stations for voice, telegraph, TV, telemetry and radar video information; data transmission equipment; antennas; command control systems; timing equipment; range interference control monitoring equipment; communication systems for range instrumentation ships and range and recovery aircraft.

Test operations on major U. S. military space systems are conducted at these ranges, as well as all civil space project launches.

Apollo Tracking Network (NASA)

Collins — Prime for Unified S-Band Network. Includes nine tracking and data acquisition stations with 30-foot antennas and 29 partial electronic systems for installation throughout the world. Tracking, telemetry, up data, television and voice communication are unified in this single system.

Scientific Satellite Instrumentation (NASA, Navy)

University of Iowa — Program director
Collins — Technical assistance and consultation, ground telemetry demodulator, converter and satellite command receiver.

Launch of Injun III satellite for studies of natural and artificial radiation zones, auroras, air glow and VLF phenomena, December, 1962. Injun-Explorer satellite launched November, 1964.

For complete information on the Collins systems for any of these projects, call or write today.

COLLINS

COLLINS RADIO COMPANY • Dallas • Cedar Rapids • Newport Beach, California • Los Angeles • New York • Washington, D. C. • International Division, Dallas

Circle No. 7 on Subscriber Service Card

Study May Ease Rotation Problems

Grumman experiments indicate two methods to counter vestibular stimulation effects at speeds up to 8 rpm

By Heather M. David

A MEANS OF NEUTRALIZING the effects of rotation such as might be produced in a rotating space station may have been discovered in a study by Grumman Aircraft Engineering Corp.

During a series of experiments that have been running over the past two years, a research group led by C. E. Wenzel has concluded that a rotating space environment can be quite comfortable and desirable at radii as small as 25 ft., rotating at up to 8 rpm and in emergencies as high as 12 rpm.

Two ways were found to raise both the rpm and the comfort level of the space station simulator, and theoretically, the space station. The first involves mobility in relation to orientation of the subject avoiding those movements that cause stimulation. The second, which Wenzel calls neutralization, uses a counter-stimulus to cancel out the coriolis stimulus.

This coriolis effect, which is caused by the force generated by the radial component of velocity, is the one, which, by stimulating the vestibular organs, has caused nausea and discomfort in many experiments and has been considered the limiting factor in the number of rpm's humans can endure.

This limit has generally been considered to be 4 rpm, although scientists are beginning to demonstrate that it could be raised, especially if the floor of the rotating cabin is tilted while on Earth to produce the same angle of force that would occur at the same number of rpm's in a weightless condition. In a recent test at General Dynamics/Astronautics (M/R Nov. 23, p. 26), four test subjects were whirled around in a tilted cabin for several days at 6 rpm without ill effects.

- **Testing procedure**—Experiments have been conducted on the 46-ft.-dia. centrifuge at Grumman's Bethpage facility. A room measuring 10 x 8 x 8 ft. was positioned over the hub of the centrifuge and at different points along one arm out to the maximum radius of 22 ft. 3 in. at the outer wall.

The room was virtually free of sensory cues, since it was noise-, light- and vibration-free. Thus, only by the subject's own feelings, through his inner ear and other body proprioceptors, could he know the vehicle was operating. Within the room was a chair, bolted to the floor in the forward-facing position.

After a series of runs to familiarize the reseachers with the problems (M/R April 15, 1963, p. 35), it was discovered that if the subjects kept their heads lined up with the centrifuge's rotation axis, the head could be turned without any adverse stimulations. The term relief axis was then given to any axis parallel to the axis of the centrifuge.

Using this technique, one subject walked around the room for 25 minutes while it was undergoing revolutions as high as 11 rpm without any ill effect. Although Grumman's first experiments were made with the whole room tilted, the group later decided to work with the cab over the hub of the centrifuge on the flat plane, since it was too difficult to find the relief axis in the tilted room.

A few tests were also run in aircraft weightless maneuvers, to see if coriolis stimulation would be the same in weightlessness as it is at 1-g. Although Grumman's runs were inconclusive, flights made about the same time by the Aerospace Medical Research Laboratory at Wright-Patterson AFB, Ohio, showed that the results should be the same—that is, independent of gravity.

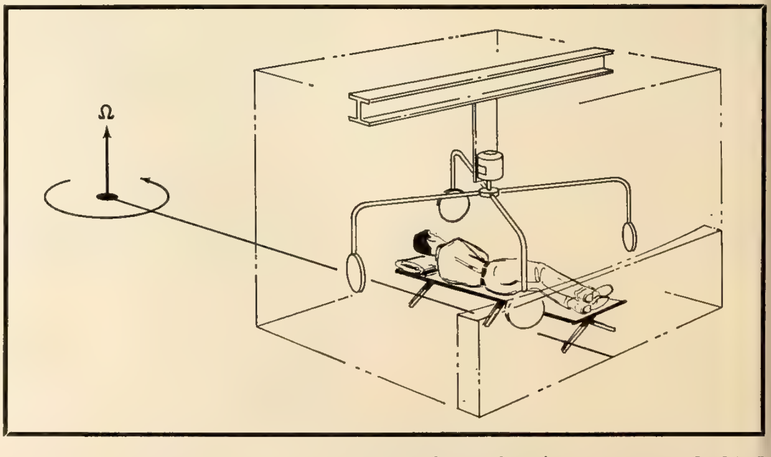
- **Mobility results**—Next phase of Grumman's work concerned the types of movements that could be made in the space station. In addition, the researchers wished to determine whether an axial or planar environment would make the best space station orientation.

Tilt tests, in which the cab was placed along the arm of the centrifuge and tilted, were conducted. However, the subjects had considerable difficulty walking, probably because the floor was flat, the researchers said. A conical catwalk was constructed. At 11 rpm, it was found that the subjects could walk without instability at 45 degrees of tilt.

The group also found that subjects could walk in circles around the hub of the centrifuge in perfect balance if they moved their feet in the same manner as a skater rounding a corner. Straight lines through the hub could be performed easily by leaning against the coriolis acceleration.

Experiments also were conducted with the subjects walking on the wall, supported horizontally by two slings. By certain maneuvers, high rotation rates also could be withstood and normal

Neutralization test rig.



tasks performed, including deep knee bends and running in place.

- **Neutralization**—The rotating Barany chair was modified by placing a large cardboard box over the top. This box, with the forward wall about three feet from the subject's eyes, eliminated external light leaks.

The room in which the chair was placed was dimly lit. A relatively bright light, in the form of a 25-watt bulb hanging through a hole in the ceiling outside the box, could be turned on. This bulb did not rotate with the chair.

A paint can with three small holes in it was placed over this bulb in such a way that as the chair rotated, the three spots of light would rotate within the box in a direction opposite to the chair's motion, but at the same rate.

Without these lights, the researchers found the subjects, rotating at 12 rpm, became nauseated and had the illusions common to this type of rotation. However, by focusing on the rotating spots of light, the stimulation almost completely disappeared. It was concluded that stimulation of the eyes can counteract any signal given by the vestibular organs. Some difficulty was encountered in duplicating this effect in the space station simulator on the centrifuge, but this was attributed to the fact that the subject lay on a cot.

The researchers attempted to duplicate the effect in the space station simulator by using four orange-painted pie plates instead of the lights. These plates were fastened to the ends of 7-ft. aluminum tubes, which were driven by a motor in the ceiling of the centrifuge room. The plates were rotated counter to the centrifuge acceleration (see artist's conception).

However, the cot probably complicated the experiment since it "pulled" on the subject. The researchers concluded that the sling was more satisfactory since it moved with the body.

Other tests are planned using a continuous motion picture strip and one in which the Grumman group will attempt to simulate sleeping in a space station, to see if the astronaut can "neutralize" upon awakening in the morning, and stay in this condition as he rises.

- **New simulators**—Two designs for simulators were conceived with which, presumably, these problems could be worked out. The first, which they called the advanced short duration simulator, would place the test subject on his side supported by two metal rings. His helmet would have a pin lock that would hold it in place, although it could be unlocked so that he could turn over.

The whole assembly would be suspended from a cross bar, which in turn would hang from the end of a rotating beam. The subject would then perform on his side on the inside of, in effect, a rotating vehicle. This simulator would be useful for studying coriolis and centrifugal effects on mobility at different rpm and radii, for axial, planar and radial motion, the researchers said.

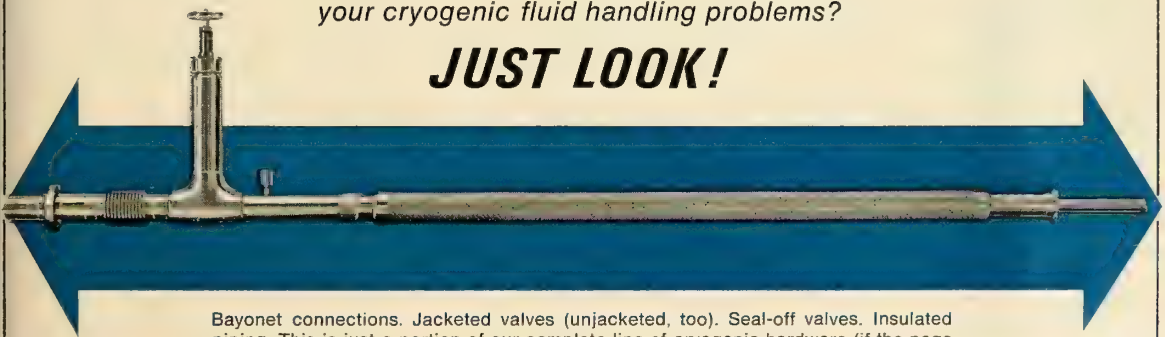
The second vehicle would be for investigating prolonged exposures to rotation. This cabin, divided into working modules, would be placed over the hub of the centrifuge or as near it as possible to minimize centrifugal forces. According to the researchers, the walls and floor would be painted with circles and straight lines to aid walking and orientation with the coriolis forces. The center of the room would be used for neutralization exercises.

In addition to developing the kinds of movements necessary to adapt to this kind of rotating environment, the group has added exercises to remedy "the more than usual stiffness" the subjects might develop from holding their heads in certain positions.

The group concluded that the optimum size for such a research simulator would be one with at least a 25-ft. radius. At this radius, 8 rpm would provide ½ g, and 11 rpm, 1 g, for emergency operation. Except for the unknown condition of sleeping, the Grumman group reported, 11 rpm thus far has been tolerated with only minor discomforts. ■

What has CryoVac done to solve your cryogenic fluid handling problems?

JUST LOOK!



Bayonet connections. Jacketed valves (unjacketed, too). Seal-off valves. Insulated piping. This is just a portion of our complete line of cryogenic hardware (if the page were wider we could show you more) we think will help solve your cryogenic fluid handling problems. ☐ Our engineers were unable to find commercially available components that would meet the exacting specifications necessary for our cryogenic transfer line systems. As a result they developed this complete line of proprietary cryogenic hardware. It solved our problem. And as we said, we think it will solve yours, too. Why not find out for yourself. You can by writing and asking for complete information on our cryogenic transfer line systems.

cvi ®

CryoVac
INCORPORATED
COLUMBUS 12, OHIO

Circle No 8. on Subscriber Service Card

Boeing Scientists Find Unexpected Abundance of 'Hot Spots' on the Moon

NEW YORK—A team of Boeing scientists just returned from a trip to Egypt, where they made extensive heat-map measurements of the Moon during the Dec. 19 total eclipse, reports that a quick look at data shows hundreds of "hot spots"—areas of surface temperature anomalies.

The experimenters, from Boeing's Scientific Research Laboratories in Seattle, had not expected to find more than a few dozen such areas.

Their measurements were made in both the infrared and visual portion of the spectrum, to aid in correlating locations of hot spots with the lunar terrain. Scientists say these newly observed areas of high temperature may well correspond with crater locations; if they do not, however, the source of the anomalies will be of major interest to lunar researchers.

The experimenters made twelve 20-minute scans of the Moon during the eclipse, three of them in the total eclipse phase. The largest anomaly observed was at the crater Tycho, where the temperature in the crater (—123°F) was found to be 86° hotter than the surrounding terrain (—209°F). Primary craters, in general, are reported to be hotter than the surrounding terrain, which is believed to be an important indication of a less dense dust cover in the crater areas, since the dust would normally act as an insulator.

- **Egyptian operation**—The three-man, company-funded Boeing expedition, which cost about $20,000, worked from the United Arab Republic's Helwan Observatory, east of Cairo, using the observatory's British-built 74-in. reflecting telescope, and detection and recording equipment brought from the United States. The IR detector was a mercury-doped germanium device which required cryogenic cooling (to —420°F) with liquid neon. This, incidentally, is believed to be the first time that liquid neon has been transported outside the U.S.

The simultaneous time-shared visual light measurements were made with a photomultiplier and chopper arrangement operating at about 450 cps. All data was recorded on magnetic tape.

Selection of the Cairo site for this eclipse made it possible to map the full Moon, both with IR and visually prior to the eclipse for purposes of comparison and for correlating terrain features, since no visual measurements could be made during the period of totality. The Boeing team had been thwarted in an earlier eclipse opportunity by bad weather in the Mt. Wilson, Calif., area.

The Boeing data is expected to yield a rather quick analysis in about a month's time. More extensive study and correlation will be conducted for almost a year. ■

Van Allen Belts May Come from Tail of Magnetosphere

THE VAN ALLEN radiation belts probably have their source in the comet-like tail of the magnetosphere extending from the dark side of Earth away from the Sun.

Spiraling protons and alpha particles emitted by the Sun are shielded from solar wind in this area. Affected only by the geomagnetic field, they are picked up by the magnetic lines of force and conveyed to the Van Allen belts.

New data collected by particle energy spectrometers and other instruments aboard *Interplanetary Monitoring Platforms I & II* (*IMP I & II*) and *Eccentric Geophysical Observatory* (*EGO*) have led to this tentative conclusion. The findings were described by Dr. John H. Wolfe of NASA's Ames Research Center, who has experiments aboard the satellites, at the New Year's meeting of the American Geophysical Union in Seattle.

Data collected from as far out into space as 96,000 mi. revealed that interaction of the solar wind and the geomagnetic field around the sunlit side of Earth creates a boundary region 2½ Earth diameters thick at a distance of five Earth diameters from the point on Earth closest to the Sun. This expands to six diameters thick 90 degrees around Earth.

Hydromagnetic effects in this boundary deflect solar radiation around Earth and prevent it from penetrating directly to the relatively low altitudes of the Van Allen belts, except during the more energetic solar storms.

Thousands of electron-volts of energy are added to the solar radiation by the hydromagnetic waves. Solar-particle temperatures in the turbulent boundary are above 1,000,000°K, compared with 100,000° in the undisturbed solar wind.

- **Fallen theories?**—Wolfe said the previously held theory that the radiation belts were produced by a sort of shock-wave effect are disproved by the fact that alpha particles (helium nuclei) and protons do not react in the same ways in the magnetosphere boundary region. Relatively few alpha particles reach the Van Allen belts.

Satellite data also indicate that the comet-like tail of Earth extends directly along the line from the Sun through Earth, rather than being slightly deflected as had been believed. Wolfe said the tail appears to be less tapered and more nearly cylindrical than had been expected, and extends at least as far as the orbit of the Moon.

Facility Tests Solids in Environmental Conditions

A NEW $150,000 rocket test facil-y has been installed by Associated esting Laboratories, Inc., in its re-ently built environmental test labora-ory near Wayne, N.J. Designed and uilt by the firm, it will be employed or test firings of small solid-propellant ocket motors at simulated altitudes up o 200,000 ft., and at temperatures anging from —100 to +300°F.

The plant is already in use. Tests re being conducted for Avco Corp. n low-thrust attitude-correcting rocket notors.

• **Test chamber and stand**—The ew facility contains a relatively large ltitude/temperature test chamber meas-ring 12 x 12 x 24 ft., built by the ethlehem Steel Corp. Rocket tests are onducted at simulated altitudes which re held essentially constant during ac-ual firing.

A temperature shroud with thermal ransfer fluid flowing within its walls s employed to enclose the rocket motor nder test, but it is removed just before est firing.

Located inside the chamber is 1,000-lb.-capacity, single-component, hrust-measuring stand developed by llegany Instrument Co. The stand pro-ides the low deflection and precise lignment necessary for high-accuracy esting. Load cells and flexures, which omplete the chamber installation, also vere provided by the Textron Elec-ronics Inc., division.

• **Calibration and instrumentation** —The thrust-measuring load cell and nstrumentation are calibrated by ATL efore and after each test. An Alinco ydraulic press provides up to 10,000 bs. loading on a standard load cell nechanically in series with the cell to e calibrated. A portable transducer alibrator reads the load cell outputs o a resolution of 0.0003%.

Four transducer signals are provided o the test console, including two analog hrust signals from the dual-channel, hrust-measuring load cell that provides one channel of redundant data. Other nputs include pressure transducer signals for chamber vacuum and thermocouple signals indicating temperature within the test shroud around the motor.

Console equipment includes four Alinco sensor analog modules (SAM-1) for the four inputs. They combine all the signal conditioning functions (excite, balance, amplify, calibrate, indicate) for each channel into a solid-state module with combined error of less than 0.02% and with cumulative noise below 7 μv RMS throughout the DC to 40-kc bandwidth.

After the input signals from the four channels are conditioned by the SAM-1 units, they are fed to an Alinco voltage-to-frequency converter whose pulse rate output is proportional to the input from the load cell or other transducer. These pulses are counted and displayed on an electronic totalizer which, in turn, is gated by an electronic time standard to operate only over the action time of the rocket firing.

Thus, the value displayed on the Alinco totalizer is an integral of time vs. thrust (or pressure, or temperature, etc.)—or total impulse. Dividing this value by the action time displayed on the time standard, the operator has the average value of the parameter sensed.

The totalizer uses an amplifier-shaper and display system to count and register pulses generated by the voltage-to-frequency converter. The integral of any analog signal during any period of time is proportional to the number of pulses counted during that time.

• **"Clock" details**—The Alinco time standard uses a 10-crystal "clock" to provide the accurate time base required. The total of pulses generated during the action time is displayed on the unit. Total pulse count is available as an output to drive an external printer.

Function of the Alinco ignition delay timer is to measure the time interval between application of the rocket ignition voltage and the beginning of actual thrust. The entire instrumentation chain is controlled by a programmer.

Manual operation can be modified to provide automatic programming and automatic calibration with outputs at various points for analog recording, peak sensing and tape recording of the digitized totalizer output. ■

YOUR INVESTMENT IS SECURE IN TAX-FREE BAHAMAS!

The advantages are many ... NO RESTRICTIONS ON PERMANENT RESIDENCE ON YOUR OWN LAND ... NO LAND TAXES ... NO BAHAMAS INHERITANCE TAXES ... NO CLOSING COSTS ... FREE DEED ... FREE TITLE INSURANCE. Land is a stable commodity—a sound investment—in this safe, secure, fast-growing area — not subject to wide fluctuations in economy or stock market. Right now we are offering a limited number of choice homesites on beautiful Grand Bahama, the fastest-growing island in the Bahamas, just 50 miles (80.5 km) across the Gulfstream from Florida, U.S.A. Become part of the social and community life on Grand Bahama where there are churches, schools, medical, dental, hospital services, stores, cinemas, businesses and booming industrial Freeport. Three 500-room hotels, and more are under construction ... luxury apartment blocks ... two championship golf courses ... marinas ... casino ... world-famous fishing and skin diving ... over 20 scheduled flights daily from Florida, plus steamer service.

Choose your homesites NOW — adjacent to all of this growth on Grand Bahama Island!

HOMESITES: *From $75 down — $75 on closing (within 90 days) balance from $15 monthly on mortgage note.

*Will accept any currency at its official bank conversion rate

AIR MAIL COUPON NOW!

SUNSHINE REALTY
777 Metropolitan Miami Building
Dept. MR-4 , Miami, Fla 33132
PLEASE SEND FULL INFORMATION

Name____________________

Address____________________

City____________________

State____________Zip Code________

Circle No. 9 on Subscriber Service Card

Boosters Pace Mars Life Detection

Ames scientist says advanced launch vehicles will allow the heavier payloads needed for sophisticated experiments

by Rex Pay

MOFFETT FIELD, CALIF.—Life-detection experiments on Mars should be delayed until advanced boosters and effective descent systems make it possible to land large payloads, says Dr. Richard Young, Chief of the Exobiology Division, NASA Ames Research Center.

This would mean a search for extraterrestrial life could not be carried out until the 1973 *Voyager* mission, at the earliest.

Young also declared that the heavy payloads of the *Voyager* spacecraft should not be looked on as a chance to extend *Mariner*-class experiments, but as an opportunity for a new start on experiments not born under severe weight restrictions.

The Ames Exobiology Division contains the NASA team of scientists probably best able to advise on selection of experiments to detect extraterrestrial life. It has recently been studying guidelines and ground rules for life-detection experiments and has prepared a comprehensive report on its findings.

Main areas of study in the division in the past have been the processes of chemical evolution (particularly those expected on Mars) and the ability of living organisms to survive simulated Martian conditions.

The group's recent study was aimed at finding the minimum set of experiments that will positively identify life on Mars. Young believes that even this minimum set will constitute a complex payload. The Aeronutronic Division of Philco Corp. is studying the engineering feasibility of such complex integrated sets of experiments (the *Automated Biological Laboratory* [*ABL*] M/R, Nov. 30, p. 87).

● **Top priority**—Many scientists within NASA feel that the agency's prime mission is detection of extraterrestrial life. For example, Dr. William MacDonald of Jet Propulsion Laboratory recently outlined priorities assigned to interplanetary exploration as: first, life detection; second, discovering the origin of the solar system; and third, understanding the Sun's mechanics.

Yet very little concerted effort has been directed to the prime objective. Young points out that NASA support of various techniques and prototype instruments for detecting extraterrestrial life has for the most part been isolated and uncoordinated. He believes that efforts to meet weight limitations have caused over-engineering of many instruments. He feels that although the principles of these instruments are worth considering, the whole problem of life detection should be reviewed, so that the requirements for an integrated experimental package can be decided on.

There is evidence of similar thinking in other parts of NASA. The *ABL* study contract awarded to Aeronutronic is one example. Another is the conclusions coming from JPL investigations into more specific aspects of life-detection hardware. For instance, a study of means of collecting samples for the life-detection instruments found that "a major technological gap exists in the interface between the scientific instruments and the planetary surface."

● **What's needed**—In an interview with MISSILES AND ROCKETS, Young outlined his personal view of the instruments needed for detecting life on Mars.

Because of the very large uncertainties involved in experimentation on Mars, Young thinks a single, limited, lightweight experiment of the *Mariner* type can be considered as no more than a long shot, with very little chance of success. A positive result for such an experiment would be inconclusive; a negative result could cause public disenchantment with interplanetary exploration.

Young summarizes the minimum requirements for life as a kind of circular equation:

$$\begin{tikzcd}
& \text{Macromolecules} \arrow[dr, shift left] \arrow[dl, shift left] & \\
\text{Metabolism} \arrow[ur, shift left] \arrow[rr, shift left] & & \text{Reproduction} \arrow[ul, shift left] \arrow[ll, shift left]
\end{tikzcd}$$

He thinks it highly advisable to include experiments based on all three of these attributes of life.

Chemical experiments probably will yield the greatest amount of information, but will be of limited value in terms of life detection, without additional evidence of either metabolism or reproduction. Presence of organic compounds, and even polymers such as proteins and nucleic acid, would not necessarily indicate life, since experiments have shown that important cell materials may be formed by non-biological means. On Mars, the high flux of ultraviolet light at the surface might be the source of energy for the formation of organic compounds, particularly sugars.

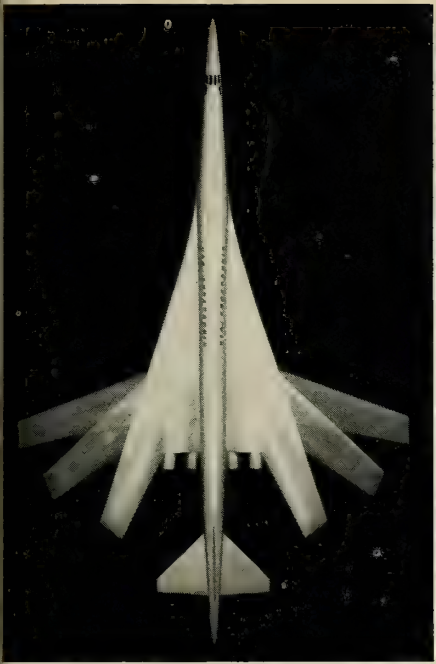
On the other hand, a metabolic or reproductive experiment that by itself yields a positive answer, even with good controls, will not be completely conclusive, says Young, because of the myriad of electronic components involved between the time of sampling and the final monitoring of experiments on Earth. Also, knowledge of Martian environments and organisms is so deficient that design of metabolic experiments requiring the function of specific enzymes is almost certain to be inadequate.

However, support from chemical analyses would negate doubts about a metabolic or reproductive experiment, particularly if the results are demonstrated on the same sample. Hence, experiments based on all three attributes appear necessary. Attempts should be made to perform analyses on the same sample or aliquots of it, and to consider that life exists only after at least one clear-cut result is obtained with a reproduction or metabolic experiment, plus supporting chemical evidence.

An aspect of chemical analysis that makes it of prime importance in life detection is that it permits detection of previously existing life or chemical pre-life stages of evolution.

● **Chemical experiments**—In the design of *Voyager* chemical experiments, certain basic assumptions must be made. Young believes the experiments must be based on characteristics of Earth biology most likely to be found elsewhere. But it is the physical and chemical manifestations of particular molecular structures that he regards as important, rather than the molecules themselves.

An extraterrestrial biological system



BOEING 727
BOEING 727

U.S. AIR FORCE

Enjoy a dynamic, long-range career with the world leader in jet transportation

he Boeing Company, today's world eader in the field of jet transportation, is lready at work on the next generation of ets — including giant military logistics ircraft, supersonic passenger liners and ther manned aircraft systems. Boeing's urrent business backlog is approximately 2 billion, of which some 60% is in comnercial jetliner and helicopter product reas. The remainder is in military prorams and government space flight conracts. This gives the company one of the nost stable and diversified business bases n the aerospace industry.

xperienced engineers and scientists who ook toward expanding the scope of their areers in this dynamic field will find proessional challenge and unique advancenent opportunities with Boeing's Airlane Division. Immediate openings are vailable at both Renton (near Seattle), Vashington, and Wichita, Kansas, for ualified graduates in engineering, physics, mathematics, business administration, operations research and production management. Specific areas of assignment are listed at the right.

Salaries are competitively commensurate with your experience and educational background. Moving and travel allowances are paid to newly hired personnel. Boeing is an equal opportunity employer.

Send your resume, today, to:

Mr. Thomas Sheppard, ***Airplane Division***
The Boeing Company, P.O. Box 707-BAK,
Renton, Washington 98055

or

Mr. Gerald Caywood, ***Airplane Division***
The Boeing Company, Dept. MR18,
Wichita, Kansas

BOEING
AIRPLANE DIVISION

Other Divisions: Aero-Space • Turbine • Vertol
Also, Boeing Scientific Research Laboratories

DESIGN ENGINEERING

- **Structural**
- **Electrical Systems**
- **Hydraulic Systems**
- **Air Conditioning & Pneumatic Systems**
- **Aircraft Control**
- **Power Plant**
- **Fuel Systems**

DEVELOPMENT ENGINEERING

- **Flight Control Systems**
- **Structural Dynamics**
- **Stability and Control**
- **Propulsion**
- **Weights**
- **Environmental Control**
- **Weapons Delivery Systems**
- **Antenna Systems**
- **Feedback Control Systems**
- **Radar Technology**
- **Metallurgy and Mechanical Engineering**
- **Non-metal Materials**
- **Military Operations Analysis**
- **Support Equipment / Facilities**

may contain polymeric material, but not necessarily protein, nucleic acids and carbohydrates. Similarly, the amide linkage, the helical structure, and the capacity to hydrogen bond are all more universal than a set of 18 specific amino acids.

Young thinks a search should therefore be made for certain general chemical characteristics: Firstly, a liquid solvent system (undoubtedly a polar molecule) capable of dissolving ionic species and solvating polar functional groups. Detection would be feasible by gas chromatography, mass spectrometry, and infrared spectroscopy.

Secondly, polymer formation, particularly organic polymers. Sample preparation and soil particulate matter would interfere with some techniques for detecting this, but osometry, ultracentrifugation and perhaps viscometry merit further investigation.

Thirdly, the ability to rotate the plane of polarized life is always associated with life. Polarimetric instruments lack sensitivity and are subject to interference from particulate matter.

Fourthly, carbon-based chemistry should be sought. A simple instrument sensitive only to organic carbon is needed. This will prevent the waste of spacecraft resources in looking for specific organic compounds in a sample with no organic carbon present.

Young thinks reduction of specific compounds to known derivatives is apt to provide a more flexible scheme of analysis than search for only one particular compound. Protein, nucleic acids, lipids and carbohydrates should be looked for. For any analysis, there is a need to prepare samples by a device that can extract, filter, strip off solvents, and perform simple chemical reactions. Only after rigorous purification, separation, and formation of derivatives will any analysis provide results that can be viewed with confidence.

Inorganic analysis of the soil to provide an understanding of the results of biological experiments will also have to be included.

All of the experimental techniques proposed by Young will involve instrumentation common to several analyses. This calls for a versatile sample plumbing system—so that samples can be transferred from one instrument to another for meaningful correlation.

• **Metabolic experiments**—The metabolic experiments must be specific enough to eliminate non-biological changes. In fact, the possibility that non-biological systems can mimic living ones suggests that a "sterilized" control experiment will always be necessary. The further possibility that the non-living system might be affected by the sterilizing agent also complicates the picture.

Changes in pH and Eh would be relatively easy to monitor, and the controls needed are likely to be fewer than with many other parameters. Young suggests other measurements might include measuring the changes of solutes in a medium or increase in temperature in a closed system; for these experiments, controls would have to be carefully designed.

However, a definite advantage in measuring parameters like this is that the kinetics of the reaction might also be indicative of a reproducing system. The kinetics of carbon dioxide production of an exponentially growing bacterial culture are peculiar to that kind of system.

Another kind of metabolic study is search for a particular enzyme or substrate of an enzyme. According to Young, the serious disadvantages of this approach include the instability of most biologicals to sterilization and the fact that only parts of a living system are detected and not life itself. A more serious drawback is that our knowledge of the chemistry of Martian organisms and their environmental conditions is insufficient to predict the reaction requirements of specific Martian enzymes.

One of the main problems in the design of metabolic experiments is the selection of substrates. Young pointed out that our total ignorance of possible life forms on Mars allows three possible approaches. One assumes that all metabolic schemes are universal; it uses a single substrate such as glucose. The second assumes that some metabolic schemes are common; it includes a whole array of substrates. The third assumes that organisms can use materials in their immediate environment; it therefore attempts to use these by extraction or by *in situ* experiments.

Young suggests that a simple and more general end-product of metabolism may prove extremely useful as a life-detection criterion. This is the production of heat as a metabolic activity. Microcalorimetry of a soil sample does not require the provision of an unknown substrate, but is an *in situ* experiment.

Because metabolism is an attribute of life that usually appears in a continuous manner, it is the parameter considered to allow maximum flexibility in design of life-detection experiments, particularly if several parameters are used to monitor metabolic activity. For this reason metabolic experiments rate a very high priority, perhaps the highest, in design of a life detection experiment.

Unfortunately, Martian organisms probably must go through a daily freeze-and-thaw cycle, and in the frozen state metabolism is non-detectable. On Mars, consequently, evidence of metabolic activity would have to be sought during warm periods, or, less preferably, on artificially thawed samples.

• **Reproduction experiments**—Th unequivocal demonstration of reproduction on Mars probably would be th most dramatic and convincing means o life detection. However, the diurnal and seasonal temperature variations on Mars are such that an observation may wel be made at an inopportune time and give a negative result.

Young lists direct methods of observing reproduction as turbidity and nephelometry, conductivity, increase i sedimentable weight or volume, electronic determination of size and numbe of cells, and television microscopy. He says the combined determination o change in size and number of individua components as a function of time appears to be the most clear-cut approach, as it is difficult to conceive of a non-living process that will increase th number of similarly-sized particles i a closed system.

• **Lander instruments**—Young see the 200-lb. payload of a *Voyager* lande as a "minimum" package for life detection experiments and suggests i might include the following.

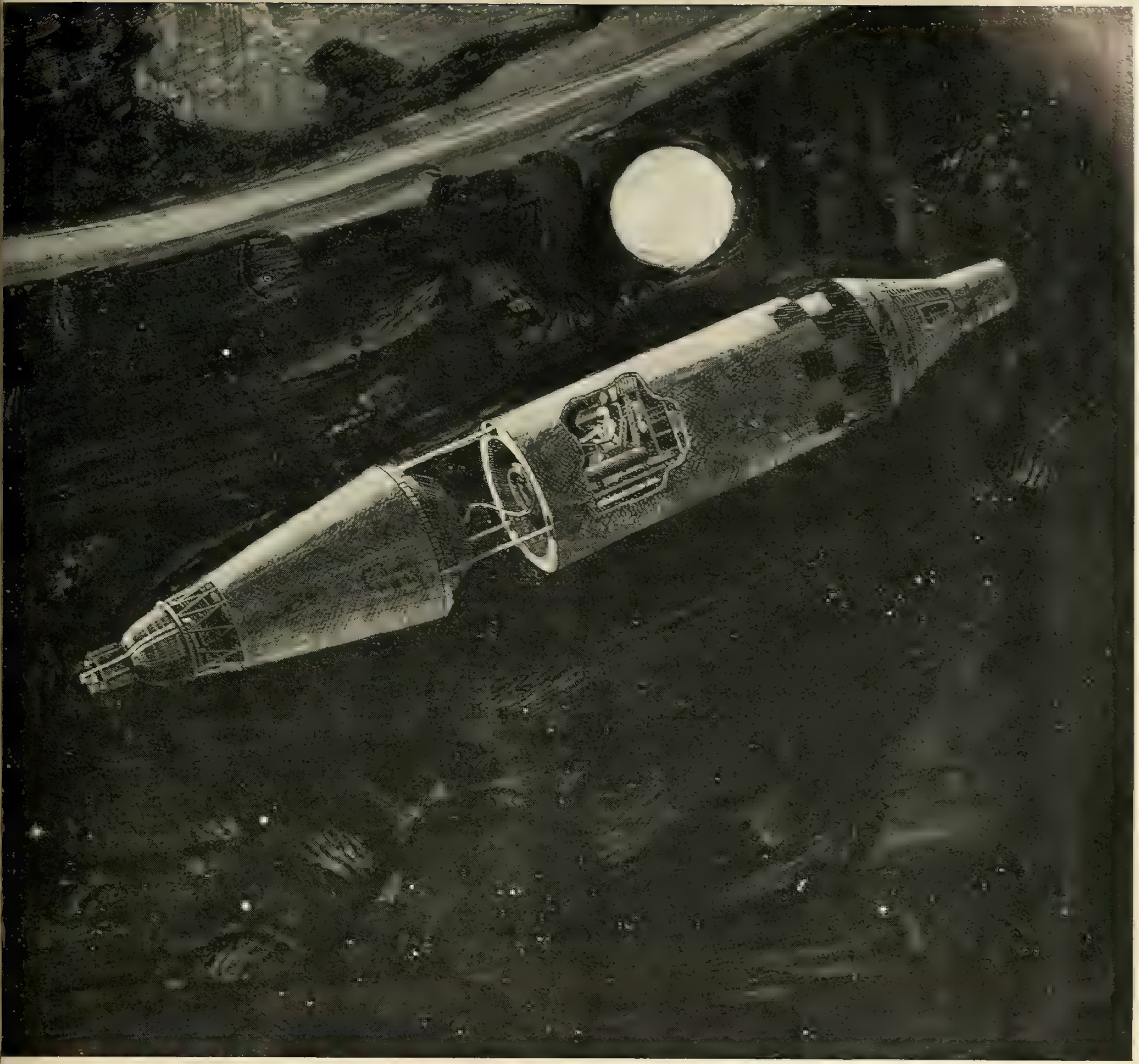
—A reproduction detection devic giving a measure of the number an size of particles in a medium as a function of time, instrumentation bein chosen on the basis of being the leas susceptible to interference from soil.

—A combination of metabolic devices measuring changes in concentration of substrate and metabolic products, using wherever possible instrumentation also required for chemica analysis—for example, mass spectrographic analysis of gaseous metaboli products, or the change in optical activity of a medium as a result of substrate depletion. A battery of specifi enzyme-substrate systems might also b included.

—A batch of experiments for analysis of the presence of organic carbo polymeric material, optically active materials, and the more significant of th biological compounds—for example amino acids. A general-survey organi analysis should be included by use o a gas chromatograph and a mass spectrometer.

—In addition to the detection instruments, provision must be made fo an adequate sampling system. It is likel that this sampling probe will not b capable of extensive drilling or digging but will have to rely primarily on material easily obtained from the surfac A device will also be needed for providing a growth medium prepared fro extracts of the soil.

The instrument package should preferably be mobile, particularly if retro-rockets will create a burnt area aroun the spacecraft. It should also b equipped for television transmission t aid in site selection.



SURVIVAL UNIT

It is a SNAP reactor system—source of long-lived electric power for life support and environment control. It will supply astronauts with heat against the cold. Purify the air they breathe. Give them light amidst blackness.

North American Aviation / Atomics International Division is developing SNAP reactors for reliable, long-lived power in space vehicles, manned space stations, satellites, and manned bases on the moon. In pioneering SNAP reactor systems for the Atomic Energy Commission, A.I. has reduced equipment as large as a house to the size of a five-gallon can.

Atomics International is one of seven divisions at North American Aviation—a corporation dedicated to advancing the frontiers of science in nuclear energy, electronics, rocketry, aviation, life sciences, and space flight.

North American Aviation

Atomics International, Autonetics, Columbus, Los Angeles, Rocketdyne, Science Center, Space & Information Systems

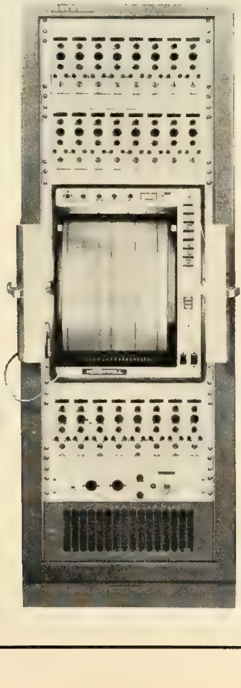
MILITARY/ AEROSPACE BUYERS:

Check these 11 ways Honeywell simplifies your data acquisition procurement.

Honeywell's experience in doing business with military and aerospace buyers has made these 11 extra services a matter of course. If you're not getting this kind of service now, call a Honeywell data acquisition field representative at Orlando, Houston, Los Angeles, Washington, Baltimore, Cleveland, Huntsville, or other aerospace-military center. Or write Mail Station 402, Honeywell, Denver Division, Denver, Colorado 80217. In Canada: Toronto 17, Ontario.

1. PRINTS For wired systems, Honeywell provides complete, interconnected wiring diagrams for the entire system, as well as provisioning prints for individual items.

2. CUSTOM ENGINEERING Each Honeywell data acquisition system, whether magnetic tape or oscillographic, is custom-engineered to your specifications. Prior to its arrival at your facility, you will have received your comprehensive Advance Information Book to speed installation, familiarization, and operation. Should you have requested advance shipment of rack hardware, mating connectors, handbooks, etc., they will also be on hand before your custom system arrives.



3. MIL SPECS Honeywell instrumentation meets many military specifications, such as for radio frequency interference. Ask about your particular MIL spec requirements... Honeywell will work with you.

4. QUALITY ASSURANCE Will Honeywell Data Acquisition Systems meet MIL-Q-9858A and/or NPC 200-3? Yessir; ask us about it!

5. SERVICE ENGINEERING Engineering teams, including engineering, application, manufacturing and quality experts, work constantly to solve your problems.

6. SPECIAL COLORS Panels can be finished to any colors in MIL standard 595 or to any other special color specification.

7. OVERSEAS PREPARATION Honeywell systems are packed for either domestic or export shipment to the exact packaging specifications that you require.

8. SPECIAL POWER Most Honeywell instruments are available for 120 or 230 volt operation at 50, 60, or 400 cycles.

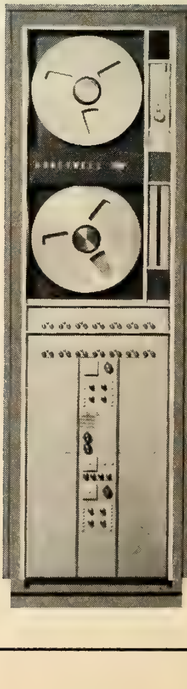
9. MANUALS Complete technical manuals are provided for all individual instruments, as well as for all packaged systems.

10. PARTS LISTS All instruments and systems are delivered with complete parts lists; MIL SPEC parts lists available on request.

11. WORLD-WIDE SERVICE All systems can be Honeywell-installed, serviced, up-dated, and maintained throughout the world. Call us today!

DATA ACQUISITION SYSTEMS

Honeywell



Mergers and Acquisitions

Raytheon Co. has purchased for an undisclosed amount of cash the Computer-Memory Div. of Philco Corp.'s Aeronutronic Div. The Aeroneutronic work is to be integrated with Raytheon computer operations in Santa Ana, Calif. . . . *Fansteel Metallurgical Corp., Chicago, has acquired Airtek Dynamics, Inc., Compton, Calif., a firm engaged in machining aerospace components and the production of pressure vessels for aircraft and missiles.* . . . Stockholders of Associated Testing Laboratories, Inc., Wayne, N.J., are scheduled to meet Feb. 1 to approve the acquisition of that company by Walter Kidde & Co., Inc. The acquisition has already received the approval of the boards of directors of both firms. Kidde expects to acquire all assets, liabilities and business of Associated in a stock exchange involving 10 shares of Associated for 3.6 shares of Kidde. In addition to offering industrial environmental and reliability testing services, Associated produces several lines of test chambers and laboratory equipment. . . . *The Deutsch Co., Banning, Calif., electronics manufacturer, has purchased Filtors, Inc., East Northport, N.Y., from General Battery and Ceramic Corp. Purchase became effective Jan. 1. Purchase price was not disclosed. Filtors, Inc., will be operated under that name as a division of Deutsch.*

Missile/Space Facilities

Electronics Associates, Inc., of West Long Branch, N.J., has moved its Huntsville, Ala., district sales office from 215 Clinton Ave. to 3322 South Memorial Parkway, Holiday Office Center, Suite 14, Huntsville. The new, larger office will house the company's servicing activities for its line of analog, digital and hybrid computers. EA services the Army Missile Command, NASA's Huntsville, western Florida, Mississippi, Tennessee and Alabama activities. . . . *General Electric Co. expects to negotiate a lease of the New York State Atomic and Space Development Authority's Malta Test Station at Ballston Spa, N.Y., by March 31. The station has been operated by GE under contract since the Authority acquired it from the Federal Government in February, 1964. Under the new arrangement, all of the station's contracts, proposals for future work and personnel will remain the same. The Authority will retain the right to make additions to the station's development and testing facilities and provide for their operation by GE or by others.* . . . NASA's Ames Research Center is hitting a new peak in expansion programs this month, with some $22 million worth of facilities presently under construction. Biggest project under way is a $4.8-million Life Sciences Building, which will have extensive biotechnology, environmental biology, exobiology and other life science research facilities. Also under construction is a $3.6-million Space Environment Research Facility, a $1.1-million Administrative-Management Building and a $1.5-million Structural Dynamics Building. To go out for bid in February is a $1.5-million building to house Ames' new $8.9-million Spaceflight Guidance Facility. Also planned for construction this winter is a $1.2-million extension of Ames' instrumentation building.

International

Eurospace has announced plans for its Second Annual USA/European Conference in Philadelphia on April 25. The conference is expected to draw top aerospace industrial leaders from Europe and the U.S. The agenda will include visits to Cape Kennedy; General Electric's Space Technology Center, Valley Forge, Pa.; Goddard Space Flight Center, Greenbelt, Md.; Aerojet General's Florida operations; Boeing, Seattle; Douglas, Santa Monica, Calif.; Hughes Aircraft, El Segundo, Calif.; Lockheed, Sunnyvale, Calif.; Martin, Baltimore and Denver; and Westinghouse, Baltimore. . . . *Bristol Siddeley Engines Ltd. has formed two new divisions, the Aero Div. and the Industrial Div. The move completes a reorganization that also involves the formation of a new Small Engine Div. last October. Aim of the changes is "increased effectiveness of day-to-day management." The Industrial Div. will be responsible for gas turbine engines in other than aviation applications and for rocket engine activities. Large aircraft engines will be the concern of the Aero Div.* . . . International Electronic Research Corp., Burbank, Calif., has licensed Japan Electronic Industry Ltd. of Tokyo to manufacture and distribute a number of IERC products. The license covers manufacture, use and sale of tube shields, tube shielded liners, heat dissipators, transistors, and related parts. Japan Aviation is a member of the Sumitomo Group.

New Activities

Boonton Electronics Corp., Parsippany, N.J., has formed an Automation Products Group as a separate engineering and marketing function within the company. Main responsibilities of the new group will be to coordinate applications engineering and sales of the firm's existing line of equipment for high-speed automatic testing of electronic components and to extend the line by providing concentrated effort on the design and development of new automatic production instrumentation. . . . *Alfred E. Lonnberg, former president of the Sanborn Co. in Waltham, Mass., has entered the consultation field in the fields of management, marketing, sales promotion and advertising. His offices are at his residence, Althora Acres, Francestown, N.H.* . . . Sprague Electric Co., North Adams, Mass., has granted the Cornell-Dubilier Corp. of Newark, N.J., a license to manufacture solid-electrolyte capacitors under Sprague Electric patents. Terms were not revealed beyond the fact that it was a "non-exclusive license with royalties." Sprague in recent months has also granted similar licenses to the Union Carbide Corp's Linde Div. and to General Instrument Corp.

AWARDS

AIR FORCE

$4,000,000—**General Telephone & Electronics Corp.,** Sylvania Electric Products, Inc., New York City, to manufacture medium-frequency antenna equipment for *Minuteman* missiles at Buffalo, N.Y., and Waltham and Needham, Mass.

$3,193,967—**Olin Mathieson Chemical Corp.,** Saltville, Va., for production of hydrazine propellant.

$2,975,000—**Garrett Corp.,** AiResearch Manufacturing Co., Phoenix, Ariz., for Phase 5 of experimental R&D work on the SNAP-50/SPUR nuclear mechanical power unit concept.

$2,900,000—**Radio Corp. of America,** Missile & Surface Radar Div., Moorestown, N.J., for the Electronic Counter-Countermeasures program.

$1,952,146—**Philco Corp.,** TechRep Div., Philadelphia, to manage and operate the precision measurement equipment laboratory located at Vandenberg AFB, Calif.

$1,894,184—**United Aircraft Corp.,** Pratt & Whitney Aircraft Div., West Palm Beach, Fla., for applied research and engineering services for design, fabrication and testing of high-chamber-pressure cryogenic liquid rocket engine components.

$1,783,500—**Douglas Aircraft Co.,** Santa Monica, Calif., for production of launch vehicle boosters.

$1,624,000—**Radiation, Inc.,** Melbourne, Fla., for production of signal monitor equipment.

$1,056,700—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for production of orbital flight systems.

$180,000—**Thompson Ramo Wooldridge, Inc.,** Cleveland, for re-direction of effort for manufacturing process for reinforced plastic solid propellant rocket nozzles.

$125,000—**Miami Valley Hospital,** Dayton, Ohio, for biochemical and physiological research support for space nutrition studies.

$99,500—**Geophysics Corp. of America,** Minneapolis, for design, fabrication, expansion and rigidization of model and full-size *MOL*-type structures.

$96,980—**Lockheed Propulsion Co.,** Redlands, Calif., for investigation of properties and characteristics of uncured solid propellant.

$94,813—**General Electric Co.,** Schenectady, N.Y., for a research investigation of the factors which affect superconductivity properties of materials.

$68,650—**General Electric Co.,** Nuclear Materials & Propulsion Operation, Cincinnati, Ohio, for design criteria for a fast energy spectrum nuclear rocket engine.

$64,000—**Technical Measurement Corp.,** Telemetrics, Inc., Santa Ana, Calif., for a Model 6253 binary-to-octal converter and a Model 6131 comparator (for Holloman AFB); and a Model 513 stored program simulator and a Model 6703 synchronizer (Patrick AFB).

$58,800—**TRW/Space Technology Labs, Inc.,** Redondo Beach, Calif., for research on Metallo organic liquid laser.

$50,000—**Callery Chemical Co.,** Callery, Pa., for R&D on high-purity, fine-particle elemental boron.

$28,200—**Martin Marietta Corp.,** Denver, for theory and operational training on the *Titan II* horizontal test equipment.

$26,383—**Johns Hopkins University,** Baltimore, for continuation of research on turbulent shear flow.

ARMY

$90,664,200—**American Telephone and Telegraph Co.,** Western Electric Co., New York City, for continued research and development work on the *Nike-X* anti-missile missile system.

$8,000,000—**Sylvania Electric Products, Inc.,** New York City, for work on classified electronic equipment.

$1,159,000—**Carpenter Brothers,** Dallas, for construction of mobile equipment maintenance building at NASA's Mississippi test facility.

$939,816—**New Mexico State University,** University Park, N.M., for non-personal services of data reduction of missile data.

$925,000—**Hughes Aircraft Co.,** Fullerton, Calif., for *AADS-70* system engineering and design.

$671,231—**Raytheon Co.,** Andover, Mass., for maintenance and modification of special tooling and test equipment for GSE for *Hawk* system.

$237,953—**American Elcon,** Cape Canaveral, Fla., for cable procurement and installation for central instrumentation facility at NASA's Merritt Island Launch Area.

$196,045—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., for a classified program.

$149,600—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for flight test units.

$81,478—**Vega Precision Laboratories, Inc.,** Vienna, Va., for S-band transponders.

$80,330—**General Dynamics Corp.,** Pomona, Calif., for long-leadtime items required under *Mauler* weapon system.

$30,638—**Ling-Temco-Vought, Inc.,** LTV Ling Electronics Div., Anaheim, Calif., for a vibration exciter.

NAVY

$11,270,030—**Electric Storage Battery Co.,** Philadelphia, for production of submarine battery cell sets.

$9,326,085—**Sperry Rand Corp.,** Sperry Gyroscope Co., Great Neck, N.Y., for new equipment, equipment alteration, technical assistance and field engineering on navigation systems for *Polaris* missile firing submarines.

$8,816,679—**Raytheon Co.,** Lexington, Mass., to produce *Sidewinder* missiles.

$6,328,000—**General Electric Co.,** Pittsfield Mass., for production of guidance equipment for *Polaris* missiles.

$1,598,092—**Associated Aero Science Laboratories, Inc.,** Torrance, Calif., for data-gathering and assessment work on missile tests.

$1,358,000—**Hughes Aircraft Co.,** Culver City, Calif., for continued production of *Phoenix* air-to-air missiles.

$767,601—**Honeywell, Inc.,** Ordnance Div., West Covina, Calif., for design and field engineering services on the *ASROC and ASROC/TERRIER* development programs.

$622,000—**North American Aviation,** Columbus Div., Columbus, Ohio, to outline a program for the production of the *Walleye* air-to-surface missile system.

$322,578—**Thiokol Chemical Corp.,** Reaction Motors Div., Denville, N.J., for facilities in support of production of the LR-62-RM-2 *Bullpup-B* rocket engine.

NASA

$4,350,000—**Radio Corp. of America,** Astro-Electronics Div., Hightstown, N.J., for the *TIROS* operational satellite system.

$4,000,000—**Northrop Corp.,** Beverly Hills, Calif., to provide support services to NASA's Aero-Astrodynamics Laboratory.

$2,425,000—**Radio Corp. of America,** Astro-Electronics Div., Hightstown, N.J., for an Advanced Videcon Camera subsystem.

$1,572,326—**Monitor Systems, Inc.,** Fort Washington, Pa., for data core systems and related effort.

$177,200—**David Clark Co., Inc.,** Worcester, Mass., to develop and fabricate *Gemini* flight space suit assemblies.

$173,873—**Radio Corp. of America,** Applied Research Div., Camden, N.J., for C-band laser subsystems.

$148,500—**Radio Corp. of America,** Astro-Electronics Div., Hightstown, N.J., for Automatic Picture Transmission tape recorder.

$135,690—**Motorola, Inc.,** Scottsdale, Ariz, for five range and range rate S-band transponders.

$80,000—**The Bendix Corp.,** Ann Arbor, Mich., to study the structural and chemical changes that occur in specified earth minerals when they are subjected to a simulated lunar environment.

$78,527—**Radio Corp., of America,** Astro-Electronics Div., Hightstown, N.J., for radioisotope power supply for lunar instrumentation.

$58,260—**Consolidated Electrodynamics Corp.,** Hampton, Va., for recording oscillographs.

$56,000—**Gulton Industries, Inc.,** Engineered Magnetics Div., Hawthorne, Calif., to design and develop dc-to-dc converters.

$31,985—**Hyperion Industries Corp.,** Watertown, Mass., for countdown timing system.

$21,679—**Radio Corp. of America,** Astro-Electronics, Div., Hightstown, N.J., for radioisotope power supply system for solar probe mission.

Rocket Research Corp., Seattle, for the manufacture of thruster assemblies for subliming solid control rockets (amounts undisclosed).

The Bendix Corp., Bendix Products Aerospac Div., New York City, for the study of th touchdown dynamics of the *Lunar Landin Research Vehicle* (amount undisclosed).

INDUSTRY

$1,900,000—**Goodyear Tire & Rubber Co.,** Aviation Products Div., Akron, Ohio, from Goodyear Aerospace Corp. and Hercules Powde Co., Wilmington, Del., for insulation fo the filament-wound motor case for the *Polari* first stage and second stage.

$480,000—**Cubic Corp.,** San Diego, Calif., from Textron Inc., Bell Aerospace Corp., Bel Aerosystems Co., Buffalo, to develop the distance-measuring subsystem for an electroni target location system for the U.S. Army.

$262,227—**Radio Corp. of America,** Missile Surface Radar Div., Moorestown, N.J., from Massachusetts Institute of Technology, Cambridge, Mass., on the Pacific Range Electromagnetic Signature Studies program.

$100,000—**Rotating Components, Inc.,** Bayshore N.Y., from Radio Corp. of America, New York City, for the manufacture of high-reliability blower cabinets that will be used t cool the RCA *SIB* and *S5* computers, checkout system for the *Saturn* rocket.

D. B. Milliken Co., Arcadia, Calif., from Hughes Aircraft Co., Culver City, Calif., for eigh high-speed motion picture cameras to be used in the Navy's *Phoenix* missile system program to evaluate missile separation and ejection (amount undisclosed).

H. K. Porter Co., Inc., National Electric Works Electrical Div., Pittsburgh, from North American Aviation, Inc., Rocketdyne Div., Canoga Park, Calif., for *Redhead-Roadrunner* rocket motor case production (amount undisclosed).

ATOMIC ENERGY COMMISSION

$400,000—**Aerojet-General Corp.,** Nucleonics Div. San Ramon, Calif., for a research and development program in the field of fissiochemistry. Approximately another $400,000 will be provided by Aerojet-General toward the project.

U.S. ARMS CONTROL AND DISARMAMENT AGENCY

$80,000—**The State of New York,** Department of Labor, Division of Employment, for a study of the impact on the Long Island labor force of defense contract phase-outs. ($400,000 of contract funded by DOD.)

$53,739—**Denver Research Institute,** Denver, to prepare a series of industrial conversion case studies.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Office of Naval Research
Washington, D.C. 20360

ONR has received an unsolicited proposal from Univac Div., Sperry Rand Corp., Bluebell, Pa., to provide for the planning, organization and administration for a symposium on microelectronics and large systems. The proposal is under consideration.

Rome Air Materiel Area
Griffiss AFB, New York 13442

Negotiations will be conducted with RCA Applied Research Laboratories, Camden N.J., under a purchase request for an investigation of high-power microwave Cerenkov generation. RFP not available; for information only.

National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia

Langley Research Center is proposing a 12-month extension of an existing study contract, NAS1-3601, on a mapping study of the radiation-safe corridor. Negotiations will be conducted with Republic Aviation Corp., Farmingdale, N.Y. RFP's not available; for information only.

U.S. Army Engineer District, Los Angeles
Corps of Engineers
751 South Figueroa Street
Los Angeles, California 90017

Bids to open 1/5/65 for launch complex and facility modifications for *Agena,* Vandenberg AFB, Calif. Plans and drawings available for $4 (half size) and $10 (full size).

AIRCRAFT ENGINEERS

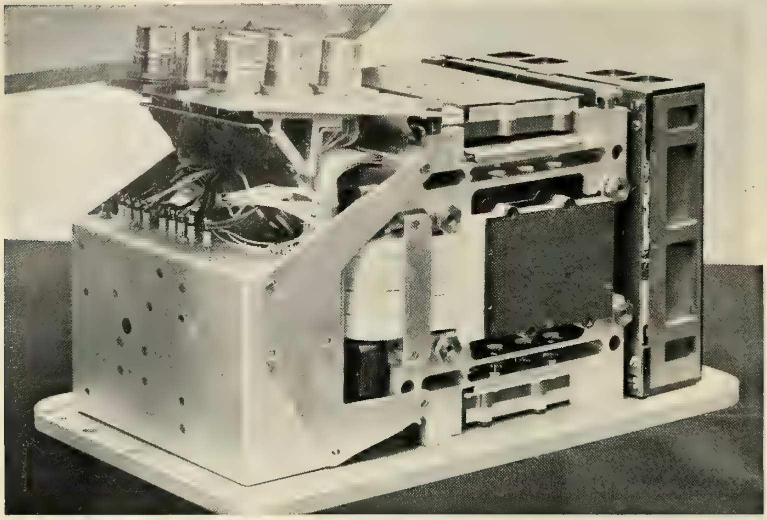
Douglas is expanding...
offers outstanding opportunities for you!

Douglas is humming with great new aircraft programs. Coming up are bigger, longer-range versions of the DC-8 jetliner and DC-8F jet freighter. Big things are happening on the new DC-9, which will double the places travelers can visit by jet. Also growing rapidly is a huge program on what will be the biggest jet transport in the world. In progress are military and commercial programs that will extend through the next decade and beyond.

Right now we are urgently seeking aircraft engineers with BS or advanced degrees who have experience in any of the following: Aerodynamics; Stress Analysis; Load Analysis; Dynamic Analysis; Electrical Design; Structural Design; Power Plant — Thermo-Mechanical; Flight Test Instrumentation; Flight Test Data Analysis; Reliability; Advanced Systems Engineering. Openings include a number of senior positions.

For full information, please send resume to Mr. C. B. Carrico, Professional Employment, Douglas Aircraft Company, 3855 Lakewood Boulevard, Long Beach, California. An equal opportunity employer.

DOUGLAS
AIRCRAFT DIVISION



New Product of the Week:

Aerospace Computer

Production models of the Univac 1824 microelectronic aerospace computer are now available from Sperry Rand Corp.'s Univac Defense Systems Div. The device represents the first successful association of thin-film memory with 100% integrated circuitry in an operational aerospace computer, the firm says.

The thin-film memory consists of 4,096 48-bit words of non-destructive readout and 512 24-bit words of destructive readout. According to the company, the device has successfully met the reliability, weight, power consumption, acceleration, vibration and temperature requirements imposed on aerospace computers.

It measures 15.5 x 9.375 in., weighs 46 lbs., and consumes 140 watts of power maximum.

Circle No. 151 on Subscriber Service Card

Microwave Absorber

A resonant-type microwave absorber, capable of continuous performance at 500°, is being developed by B. F. Goodrich Co.

The Type RF HT is a lightweight, flexible silicone foam. Bandwidth at X-band exceeds 1.11:1 at the 20-db level. Incident energy reduction is 25 db at the resonant frequency. Specifications include 0.25 lbs. per sq. ft. at X-band; 0.43 lbs. per sq. ft. at C-band and 0.78 lbs. per sq. ft. at S-band. The material is available in sizes of 1 to 4 ft.

Circle No. 152 on Subscriber Service Card

Helium Dewar

Applied Physics Corp. is marketing a liquid helium dewar that features low thermal mass, special insulation and a built-in cryogenic pump.

The 4 x 14-in. device will take solid samples 22 x 3 mm normal to the beam and up to 12.5 mm thick, and liquid samples in special cells up to 12.5 x 125 x 27.4 mm. Sufficient vacuum for operation can be achieved with a mechanical pump in less than 30 minutes. Time from room temperature to liquid helium temperature is 2 hrs.; holding time for a full dewar (0.4 liter) is 3 hrs. Argon, hydrogen, neon and nitrogen may also be used in the dewar.

Circle No. 153 on Subscriber Service Card

Surveillance Receiver

A surveillance receiver, the Type 965, has been designed to receive signals from 10 to 90 mc and is now available from Communications Electronics, Inc.

Unusual in its reception of signals from both the HF and VHF spectrums, the receiver was specifically intended for applications reliably covering the range just above and below 30 mc. The unit receives AM, FM and CW, incorporating separate RF tuners for 10-30 mc and 29-90 mc.

Three IF bandwidths (10 kc, 50 kc and 200 kc) are switchable from the front panel, with a variable BFO activated for CW reception in all thre bandwidth positions. Choice of manua or automatic gain control is offered fo AM. Audio, video, IF and signal monitor outputs are provided, the last two a 21.4—facilitating use of a CEI signa monitor if a visual display is desired.

Circle No. 154 on Subscriber Service Card

UHF Tuner

General Electronic Laboratories Inc., is marketing a UHF tuner capabl of extending frequency ranges of receivers from 250 to 1,000 mc.

The Type 65A1 can be used wit any receiver tunable to 60 mc. The frequency range is covered in two band —250 to 500 mc and 500 to 1,000 mc Noise figure for the low band is 10 db maximum and 12 db maximum for the high band. Image and IF rejection are 65 db and 75 db minimum respectively

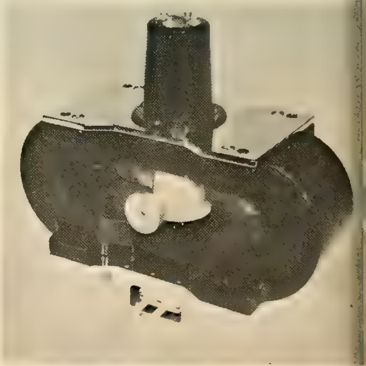
The device measures 3.5 x 12 in and can be mounted in a standard 19 in. rack.

Circle No. 155 on Subscriber Service Card

Klystron Oscillator

A two-resonator, fixed-tuned klystron oscillator, capable of producing 12-w output at 55 gc, is being marketed by OKI Electronics of America.

The Model KC 55B incorporates a unique ceramic structure, for stable operations and long life, and a permanen magnet, the firm says. The device i



cooled by a liquid flow of 1.5 quarts/ minute. It measures 9.3 x 8.5 x 4 in. and weighs 13 lbs., 7 oz.

Characteristics include a resonator voltage of 3.9 kv maximum; control electrode voltage of —300/—150v dc collector voltage of 4.9 kv maximum cathode current of 200 ma maximum resonator current of 70 ma and heater voltage of 7.5v maximum. Warm-up time is 60 seconds.

Circle No. 156 on Subscriber Service Card

Kerr Shutter Delay

The Model KD-1000 and KD-2000 err shutter delays, available from appa Scientific Corp., are inert-gas-yratron pulse generators with fast-ising, exponentially falling pulse output. Rise time less than 20 nanoseconds, mplitude 500v.)

They are used in laser giant pulse xperimentation to program Kerr shut-er operation with respect to the flashing umping cycle. The high-voltage, low npedance output is designed to drive ydrogen thyratron circuitry in a high-oltage pulse generator.

The Kerr shutter delay delays the utput of a pulse generator with respect the synchronization input signal. The D-1000 operates over a range of 0 to 000 microseconds in 50 microsecond eps; the KD-2000 over 0 to 2000 icroseconds in 100 microsecond steps.

Circle No. 157 on Subscriber Service Card

weep Oscillators

A series of sweep oscillators and ront panel oscillator plug-ins to pro-ide electronically swept or stable signal requency coverage from 250 mc to 40 c is available from Alfred Electronics.

Typically, the Model 650 is said to rovide 1 to 8 Gc coverage for approxi-ately the same price as 1 to 4 Gc cov-rage in other instruments. Oscillator lug-ins with PIN diode leveling through 2.4 Gc and grid leveling through 40 Gc re available. In PIN operation, the WO always operates at maximum ower. During square wave or pulsed peration, the BWO is turned full "on" r "off." Because of this and a low purious FM level, the Model 650 can e used in receiver test applications.

A universal time-saving F_0 control ombines three controls in one to mark requency, set a single frequency or cen-er symmetrical sweep.

Circle No. 158 on Subscriber Service Card

LF Receiver

A VLF receiver incorporating an lectronic servo along with other new eatures is available from Electronic ngineering Co.

The Model 880A measures 7 in. igh and weighs 43 lbs. with a power equirement of 40 watts. The instru-ent is a sensitive phase tracking re-eiver to be used for comparison and/or orrection of a locally generated fre-uency with any stabilized VLF carrier rom 10 to 30 kc in 100-cps increments r the 60-kc WWVB station. The unit rovides almost instantaneous tuning of he 201 possible VLF channels by means f three digital thumbwheel switches.

Circle No. 159 on Subscriber Service Card

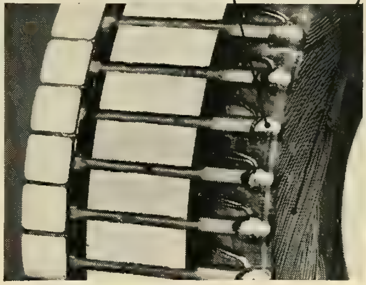
WHAT TO LOOK FOR IN A DIRECT DRIVE DC TORQUE MOTOR

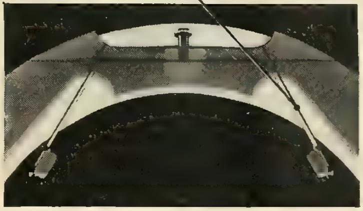
Good design assures long life and guaranteed performance. There are many details of design to consider. Two unique examples of Inland designing are bar mounts and solder joints, available only on Inland torque motors. This Inland patented* feature gives you a wrap-around solder joint that is a **reliable connection before** soldering and is **mechanically secure before** potting.

*U.S. Patent No. 2861203

Standard Inland motor armatures are potted in **clear** epoxy making it easy to inspect and **see** the quality: visible proof of Inland quality workmanship.

Only Inland motors have brush holders with no bends external to the mounting support. Not all applications need this special feature . . . but where maximum reliability is required, this feature becomes very important.





The direct drive DC torque motor has firmly established itself as a superior actuator in rate and position servo system applications. It has inherent advantages over AC, hydraulic and pneumatic actuators and systems. The direct drive torque motor delivers more torque for its size and weight than any other electromagnetic device. Because of the absence of gears, there is no gear backlash to worry about. It is a simple and compact torque motor — easy to design into your servo system.

With the increased popularity and application of DC torque motors in defense and industry, new torque motor manufacturers have recently entered the field. Confusion about specifications, performance ratings, design configurations, etc. is unavoidable under such circumstances. Inland Motor Corporation is the oldest company in the direct drive DC torque motor business and has originated most of the torque motor designs used today.

Broad engineering experience and precision-quality manufacturing techniques are the kind of credentials you should look for when buying direct drive torque motors. Only Inland offers you such credentials. Inland motors are being successfully used in thousands of different applications, in many extreme environments.

When you want to use a direct drive DC torque motor, you want reliability, guaranteed performance, long life, competitive price and the intangibles that experience, not claims, provide.

RELIABILITY Reliability is a result of sound engineering, proven manufacturing techniques and sensible ratings. Inland products meet all required military specs plus are subjected to a high order of quality control, unmatched in the industry. Every motor is tested and the results documented to guarantee performance. This data is available to Inland customers.

COST AND DELIVERY Inland offers an excellent record of fast delivery in prototype quantities. Some motors are production run: stock models usually delivered off the shelf. Standard catalog items require lead times of as little as two weeks. There is a broad choice from 600 models . . . available in only six weeks. New designs are available at a slightly longer lead time. Inland is completely competitive in price, usually with an edge on other suppliers. Our proof: people buy more direct drive DC torque motors from Inland than from any other company in the world!

Inland torque motors have many other advantages which we'll be glad to tell you about . . . send for the complete details today.

TORQY SAYS: Send for the Inland Condensed Torque Motor Selection Guide. It is full of information how, where and why to use a torque motor.

INLAND MOTOR
CORPORATION
RADFORD VIRGINIA

© INLAND MOTOR CORPORATION 1964

SUBSIDIARY OF KOLLMORGEN

Circle No. 10 on Subscriber Service Card

Crossed-Field Amplifier

S-F-D Laboratories, Inc., is marketing the SFD-220 Ku-band amplifier. The 100-kw tube is a continuous cathode, re-entrant stream crossed-field device. It is forced-air cooled and features ceramic input and output windows.

The tube offers a 20-db gain and has a typical efficiency of 30-35%. Characteristics include: frequency range, 16 to 17 gc; heater voltage, none required; peak voltage range, 13.5 to 15.5 kv; peak current range, 18 to 25 A; pulse length, 0.05 to 3 μsec, and duty, 0.001.

Circle No. 160 on Subscriber Service Card

Shorting Switches

Waveline, Inc., is marketing a series of shorting switches in seven standard models. The units cover a frequency range of 2.6 to 40 gc.

Performance characteristics include a maximum VSWR of 1.02 in open position and 125 minimum VSWR in closed or short position. Insertion loss is negligible.

For special applications, the switches can be equipped for remote control operation by incorporating a solenoid relay.

Circle No. 161 on Subscriber Service Card

Low-Frequency Inductors

A series of high-Q temperature-stable inductors for use at frequencies below 1 kc has been announced by Arnold Magnetics Corp.

The Series ILM covers the range from 2 to 300 Henries and is designed for low-frequency circuits and features high inductive stability and a minimum Q of 8 to 60 cps. They may be used as the inductive component in filter circuits at frequencies as low as 20 cps when coupled with capacitors on the order of 0.2 mfd.

Circle No. 162 on Subscriber Service Card

Displacement Transducer

A displacement transducer that requires no mechanical connection to the metal surface whose separation or motion is being sensed is available from Kaman Nuclear. The Model KD-1100 operates on a variable impedance principle and has the advantage that wide temperature changes in the material being sensed will cause practically no error in the displacement reading.

Frequency response may be as high as 0-200 kc. These units are also available in nuclear-radiation-hardened versions. The device has been designed for such applications as re-entry vehicle skin motion measurements, shock-wave interaction with mechanical structures, vibration analysis, eccentricity measurements of high-speed rotating devices, and a wide variety of deflection, compression, expansion, load, position and motion measurements.

Circle No. 163 on Subscriber Service Card

Portable Curing Oven

American Product Development Co. is marketing a portable curing oven that weighs 3.5 lbs. and measures 6 x 8 in.

The device cuts air-drying times of 2 and 5 days to 0.5 and 6 hours respectively for all typical potting compounds. The oven provides thermostatically controlled temperatures up t 500°F. Features include glass fiber i sulation, automatic timer, thermomete stainless steel walls and impact an abrasion-resistant outer walls.

Circle No. 164 on Subscriber Service Card

Solid-State Commutators

A series of all solid-state TLC com mutators has been developed by th Vector Dept. of United Aircraft's No den Div.

The devices are available in IRI standard formats, as well as speci formats, and can handle either PA or PDM.

Features include a built-in ampl fier with adjustable gain to permit a commodation of inputs from 10 mv 1v; 400-K differential input impedanc ±0.3% overall linearity; and capabilit to withstand overvoltage up to ±15

Circle No. 165 on Subscriber Service Card

Laser System

A laser system capable of using o of five different flash lamps and thre types of cooling without modificatio has been developed by Applied Laser Inc. The ruby laser system, Model 101 c2, can be operated in high-energ high-repetition rates or "Q" switche modes without involving system optic misalignment or other modifications.

In the high-energy mode, the syste delivers up to 250 joules of 1.5 millise with FX47a, XE-17 or FX77 flas lamps. With the FX77 lamps, inpu as high as 30,000 joules can be a commodated.

In the high-repetition-rate mode, th device can deliver up to 20 pulses p second at 0.5 joule per pulse or pulses per second at 10 joules per puls It uses FX65 or FX67a lamps.

In the "Q" switched mode, usin FX67a lamps, output can be varie between 1 joule in 30 nanoseconds an 10 joules in 4 microseconds at repet tion rates up to 1 pulse per second.

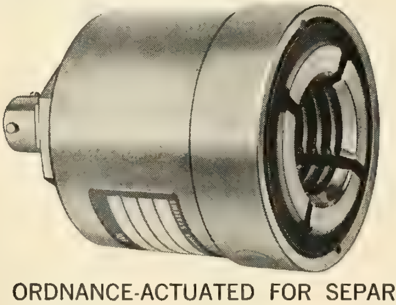
Circle No. 166 on Subscriber Service Card

Cadmium Selenide Photoce

National Semiconductors, Ltd., h developed a plastic-enclosed cadmiu selenide photoconductive cell, the Typ NSL-3531.

The vacuum-deposited unit mea ures 1.7 k ohms at 1 footcandle an 20 ohms at 100 footcandles. Minimu dark resistance is 2 megohms. Max mum voltage rating is 80v peak, ac dc, with a maximum power dissipatio of 0.2 watt.

Circle No. 167 on Subscriber Service Card



RELEASE NUTS

ORDNANCE-ACTUATED FOR SEPARATION ON COMMAND

The S02 Series is a highly reliable mechanical system that allows complete separation without fragmentation. This device is well suited to aerospace applications due to small explosive loads and retention of combustion gases. Available fully-qualified in captive and non-captive versions to meet a wide range of requirements.

Get Complete Information on This And Other Ordnance Products From

SOS

SPACE ORDNANCE SYSTEMS, INC.

133 PENN STREET, EL SEGUNDO, CALIFORNIA 90246/213-772-5461

Send for General Catalog and Capabilities Brochure

RESEARCH
DESIGN
DEVELOPMENT
MANUFACTURING

Circle No. 11 on Subscriber Service Card

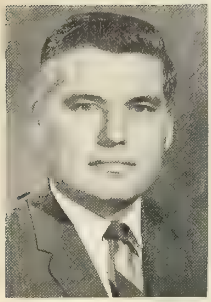
MISSILES AND ROCKETS SPECIAL REPORT:

FLUIDICS

HISTORY, GROWTH, STATE OF THE ART AND APPLICATIONS • PRESENT AND FUTURE MARKET POTENTIAL • PRESENT AND FUTURE EXPENDITURES • DESCRIPTION OF R & D EFFORTS OF PARTICIPANTS IN THE FIELD COVERING: Size of effort based on in-house and contract R & D programs • Technological approach — including material, fabrication, technique, components and/or systems types • Direction of effort —across-the-board research or specifications applications • Accomplishments to date.

Publishing date: February 8, 1965 **Closing date: January 25, 1965**

names in the news


LAW

SCHACHER

MORAN

STERNBACH

ROHNER

C. Keith Law: Named manager, defense planning, in the Radio Corp. of America's Defense Electronic Products organization.

Daniel L. Schacher: Elected vice president of Tel-Instrument Electronics Corp., Carlstadt, N.J. He is also chief engineer of the company.

Gerald L. Moran: Elected a senior vice president of Sylvania Electric Products Inc., New York City. He has overall responsibility for the chemical and metallurgical division in Towanda, Pa., the parts division in Warren, Pa., and the Sylcor division in Hicksville, N.Y.

Seymour B. Sternbach: Elected a vice president of Tenney Engineering, Inc., Union, N.J. He is also manager of manufacturing and contracts administration for the environmental division.

Gerrit J. Rohner: Named manager of Sperry Rand Corp.'s Space Support Division in Huntsville, Ala. This division will supply support services for the Astrionics Laboratory of NASA's Marshall Space Flight Center. Rohner was formerly with the Inertial Div. of Sperry's Gyroscope Co.

William Grundner: Promoted to the position of vice president of production of Drake Manufacturing Co., Chicago.

Charles R. Davis: Named president
Robinson Vibrashock Division of Robinso
Technical Products Inc., Teterboro, N
He was formerly general manager of th
division. He replaces **C. S. Robinson** wh
has retired in order to devote full time
the development of special projects and
duties of chairman of the board of Robin
son.

G. William Harrison: Appointed execu
tive vice president of MB Electronics,
division of Textron Electronics, Inc. Als
newly appointed are **A. C. Deichmille**
vice president-marketing, and **John**
Baker, vice president-manufacturing. Th
latter two positions are new.

Steven E. Belsley: Named chief of th
biotechnology division at NASA's Ame
Research Center. He was formerly assistan
chief and has been with Ames since 194

Dr. Robert S. Voris: Appointed directo
of development for Hercules Powder Co.
Chemical Propulsion Division. He wa
formerly manager of the high energy r
search division.

Joseph A. Christiano: Named vice pres
dent of Computron Inc. He was former
general manager of manufacturing fo
Computron.

Alvin W. Streitmatter and George
Struck: Elected assistant vice presidents
Eastman Kodak Co., Rochester, N.Y. Bot
are in the Company's marketing organiza
tion.

H. K. Pohlman: Elected a vice preside
of Federal-Mogul-Bower Bearings, Inc
and also general manager of the company'
Bower Roller Bearing Div. **Walter T. Cam**
has been appointed general manager of th
National Seal Div., replacing Pohlma
William C. Adams succeeds Camp as ge
eral manager of Arrowhead Products Di
William M. Dunn has been appointed ge
eral manager of the Microtech Division.

E. Dana Gibson: Appointed to th
newly created position of director of go
ernment sales at Lockheed Propulsion C
He was formerly vice president and ge
eral manager of Shawnee Industries, Inc
a subsidiary of Thiokol Chemical Co.

What's the shortest distance between these 2 points?

Los Angeles **Cape Kennedy**

San Diego Houston New Orleans Melbourne

National's direct line.

We call it our "Rocket Run." It's the only direct jet service between the major space centers of the west and Melbourne (closest airport to Cape Kennedy.)

You jet between Los Angeles and Melbourne without changing planes. National also serves the key space age cities along the east coast.

Is this any way to run an airline? You bet it is.

Jet National
coast to coast to coast

Circle No. 12 on Subscriber Service Card

let us move with you!

Six Weeks Is Required
o Change Your Magazine Address

regulation of the Post Office requires that you
y extra postage if copies of

MISSILES AND ROCKETS

e forwarded to you at your new address. Copies
ll not be forwarded free and we cannot replace
st copies. To insure delivery at your new ad-
ess please notify us at least six weeks in ad-
nce of your moving. Send us your old and new
dress, and, **if possible, the address label
om your last issue . . .** include your postal
ne or zip number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Geneva, Switzerland—10 Rue Grenus; Geneva 321044

Paris, France—11 Rue Condorcet; TRU 15-39

—when and where—

JANUARY

1965 Government-Industry Forum, sponsored by the National Electrical Manufacturers Assn., New Orleans, Jan. 18-19.

International Symposium on Solar Radiation Simulation, sponsored by the Institute of Environmental Sciences and the ASTM, International Hotel, Los Angeles, Jan. 18-20.

Conference on Quantitive Analysis and Evaluation for Production Activities, sponsored by Purdue University, Lafayette, Ind., Jan. 20-22.

Winter Meeting of the National Society of Professional Engineers, Jung Hotel, New Orleans, Jan. 20-23.

"This Case for Impure Research," lecture sponsored by the Advanced Research Projects Agency, The Pentagon, Washington, D.C., Jan 21.

National Symposium on Hydrocarbon Analysis sponsored by the ASTM, Sheraton-Lincoln Hotel, Houston, Jan. 22-23.

Symposium on Fundamental Phenomena in the Materials Sciences, sponsored by the Ilikon Corp., Sheraton Plaza Hotel, Boston, Jan. 25-26.

Second Annual Aerospace Sciences Meeting, sponsored by the AIAA, New York Hilton, New York City, Jan. 25-27.

Joint Annual Meeting of the American Mathematical Society and the Mathematical Assn. of America, University of Colorado, Denver, Jan. 25-30.

Second Winter Power Meeting of the Institute of Electrical and Electronics Engineers, Statler-Hilton Hotel, New York City, Jan. 31-Feb. 5.

FEBRUARY

Sixth Annual Solid Propellant Rocket Conference, sponsored by the American Institute of Aeronautics and Astronautics, Mayflower Hotel, Washington, D.C., Feb. 1-3.

Reinforced Plastics Division Conference, sponsored by the Society of the Plastics Industry, Edgewater Beach Hotel, Chicago, Feb 2-4.

Winter Convention on Military Electronics, sponsored by the Institute of Electrical and Electronics Engineers, Ambassador Hotel, Los Angeles, Feb. 3-5.

Unmanned Exploration of the Solar System, sponsored by the American Astronautical Society, the American Astronomical Society, American Geophysical Union, American Institute of Biological Sciences, IEEE and AIAA, Denver Hilton Hotel, Denver, Feb. 8-10.

Spring Meeting of the American Society for Testing and Materials, Statler-Hilton Hotel, Cleveland, Feb. 8-12.

Flight Testing Conference, sponsored by the AIAA and NASA, Huntsville, Ala., Feb. 15-17.

Advertisers' Index

ATLAS CHEMICAL INDUSTRIES, INC. . . 11
Agency—Harris D. McKinney, Inc.

BECKMAN INSTRUMENTS, INC., OFFNER DIV. 4
Agency—Erwin Wasey, Ruthrauff & Ryan, Inc.

BOEING CO., THE, AIRPLANE DIV. 33
Agency—Campbell-Ewald Co

COLLINS RADIO CO. 24, 25
Agency—Tracy-Locke Co., Inc.

CRYOVAC INC. 27
Agency—The Jay H. Maish Co.

DOUGLAS AIRCRAFT CO., INC. 12, 39
Agency—J. Walter Thompson Co.

EDGERTON, GERMESHAUSEN & GRIER, INC., EBW SYSTEMS ENGINEERING 2
Agency—Reach, McClinton & Co., Inc

FAIRCHILD SEMICONDUCTOR 3
Agency—Johnson & Lewis, Inc.

GENERAL ELECTRODYNAMICS CORP. . 8
Agency—Glenn Adv., Inc.

GRAND BAHAMA PROPERTIES, LTD. . . 31
Agency—Arthur R. Mogge, Inc.

HEXCEL PRODUCTS, INC. 6
Agency—Lennen & Newell

HONEYWELL 36
Agency—Campbell-Mithun, Inc

INLAND MOTOR CORP., A SUB. OF KOLLMORGEN CORP. 41
Agency—S. Gunnar Myrbeck & Co.

LOCKHEED MISSILES & SPACE CO. 7
Agency—Hal Stebbins Inc.

NATIONAL AIRLINES, INC. 44
Agency—Kenyon & Eckhardt, Inc.

NORTH AMERICAN AVIATION, INC. . . 35
Agency—Batten, Barton, Durstine & Osborn, Inc.

SPACE ORDNANCE SYSTEMS, INC. 42
Agency—Lynn-Western, Inc.

SPERRY UTAH CO., DIV. OF THE SPERRY RAND CORP. 48
Agency—Reach [illegible] Inc.

UNIVAC DIV. OF SPERRY RAND CORP. 47
Agency—[illegible]

The Merry-Go-Round

WE ARE GRAVELY CONCERNED that research and development may be the weak spot through which the Great Society drops out of the spotlight of greatness and into the darkness of national oblivion.

We have yet to see any indication from the present Administration that it understands the crucial importance of R&D. We find instead that this vital area is becoming a neglected stepchild while attention is directed toward such understandable goals as a tight budget, a détente with the Soviet Union, and war on poverty and disease.

The brilliance in research and development which leads to advancement in science and technology does not just happen. It must be nurtured carefully in the right atmosphere. That atmosphere, it seems to us, does not exist today.

We recently cited the speech in which Dr. Harold Ritchey, president of Thiokol, pointed out that the significant advances in technical achievement of the past decade came as a result of the funding of vast weapon systems such as *Atlas, Titan, Minuteman* and *Polaris*—not from direct investment in research and development. With the phase-out of spending on big strategic systems has come an end to that R&D drive. Yet there are areas of military interest in need of the large-scale funding which could produce such dividends—for example, missile defense, military space, stand-off delivery systems, deep-ocean technology, big solid boosters and nuclear rockets.

To suggest that we fund such programs for the mere sake of technological advancement might seem far-fetched; yet it is really no more so than the amount of money the nation pours each year into the production of gin or into automobiles to jam onto expensive eight-lane highways or into advertising to make those automobiles obsolescent as soon as they come off the production line.

Let us understand that we should undertake new offensive and defensive weapon systems and new space projects, not only to assure that we stay ahead of our enemies, but because of the great push forward these efforts give to our science and technology. Research and development funding for its own sake frequently is an uninspired crawl to a dead end. Out of the ICBM programs came great advances in such important fields as materials and electronics. We must show a national willingness to continue investment in such large, expensive projects. If not, we will remain tied to the status quo while others pass us.

The spending of such funds also calls for a deep understanding of research and development. To answer the questions of "What will we do?" and "When will we do it?" before answering the question of "Can we do it?" puts the cart before the horse in many areas. We must sometimes undertake development without requirements—but with objectives—in order to answer "Can we?"

In other cases, we may have to start without an answer to that question and with some vital requirements. In both instances, once there is an indication that the answer is yes, we must be prepared to take the great leaps forward in technology that will keep the nation fresh, strong and vital.

ONE PUBLIC OFFICIAL who has shown an understanding of this critical balance in research and development is Atomic Energy Commissioner James T. Ramey. In a recent speech, he talked about what he and Congressman Melvin Price like to call the "Requirements Merry-Go-Round."

Too-stringent requirements and too-ambitious cost-effectiveness can be devastating deterrents to an effective research and development program. Commissioner Ramey had something to say about both:

- *Requirements.* Simply stated, Mr. Ramey said, the basic problem is the tendency to hold back a developer's project until a specific requirement or mission is formally established by a user agency. Yet, the user very often is not in a position to establish such a requirement unless the project is permitted to move forward to the point of demonstrating its value. This is the merry-go-round. All too often, the lack of a requirement results in the death of a promising development. The danger of this was aptly summed up by AEC Chairman Glenn Seaborg when he told the Joint Committee on Atomic Energy last April: "If Hahn and Strassman had come in with a project that they were going to bombard uranium with neutrons in 1938 or something like that, nobody in the world would have been smart enough to divine at that time that that would have any practical application."
- *Cost-effectiveness.* Although cost-effectiveness studies properly applied can be useful in the evaluation of engineering development projects, Mr. Ramey notes, their utility becomes more tenuous as applied to experimental and prototype development projects. "I would conclude that the abuse of the cost-effectiveness techniques can be just as lethal to a development project as the unscrupulous use of the requirements systems."

Both of these hurdles—requirements and cost-effectiveness—tend to favor the status quo, as Mr. Ramey points out.

He adds: "Many, if not most, significant advances in technology have come as a result of the vision, intuition, judgment and dedicated energy of one man or a few men and their organizational supporters in overcoming the inertia of the status quo."

The nuclear submarine and the ICBM come to mind as two apt examples of this. We must be perceptive enough to encourage such men and willing enough to accept the financial sacrifices required to back their ideas.

Without this perception and this willingness, we will wither and die amidst a welter of gin-mills, neon-lighted luxury hotels and used car lots full of obscenely designed automobiles—die as victims not of a nuclear holocaust but of a grotesquely over-inflated standard of living and far too little imagination.

William J. Coughlin

Circle No. 14 on Subscriber Service Card

**100 million dollars blasts off...
a 31.5 pound computer takes over.**

And quite a task it is, too. But the en who are responsible for guidance nd control know that when the chips e down only one thing counts:

Either the System has it or it oesn't.

In the 1824, UNIVAC® has a tiny owerhouse — a fully microelectronic erospace computer that can really ke it—and it's *in production*. Capale of absorbing enormous shock loads, hile still remaining operational, this computer can withstand the G forces expected in missile applications.

But ruggedability is just one of so many salient features. For example: Measuring only 8" x 7¼" x 14", this 31.5 pound package consumes only a scant 110 watts of power.

Its Mean Time Between Failures, is many times greater than most larger conventional units.

Its *electrically alterable* thin-film memory allows the 1824 to perform an overwhelming amount of complex in-flight operations, without loss of vital data.

And finally, as in all UNIVAC military systems, this computer is discretely adaptable to a wide variety of missions.

The UNIVAC 1824 Microelectronic Aerospace computer is another example of the creative technology and high caliber of craftsmanship you expect from . . . **UNIVAC**®
THE FIRST COMPUTER

IVAC DIVISION OF SPERRY RAND CORPORATION

Let experience
put your
tactical missile
in the air

In-depth experience insures the success of a new missile system. Sperry Utah has depth—51 million manhours of experience—solid management achievement as prime contractor for development and production of the inertially-guided Sergeant tactical missile system. □ The Army has called Sergeant the most reliable missile fielded today. □ For three years, Sergeant on-time delivery performance has been an impressive 99.4 percent. □ Over 5,000 cost reduction ideas by Sperry personnel have netted $6.7 million in savings reflected in a higher-performance, lower-cost product. □ On the 125 Sergeant contracts administered to date, Sperry Utah management has achieved a record-breaking one/tenth of one percent obsolescence cost. *Performance*—backed by experience—is available at Sperry to guarantee the success of new tactical missile systems—air, surface or ship-launched. When it comes to tactical missiles, evaluate the team that builds the best.

SPERRY UTAH COMPANY, Salt Lake City, Utah.

SPERRY
DIVISION OF
SPERRY RAND
CORPORATION

Circle No. 13 on Subscriber Service Card

JANUARY 25, 1965

missiles and rockets

HE WEEKLY OF ADVANCED TECHNOLOGY

JAN 1965
HOUSTON PUBLIC
LIBRARY
Houston, Texas

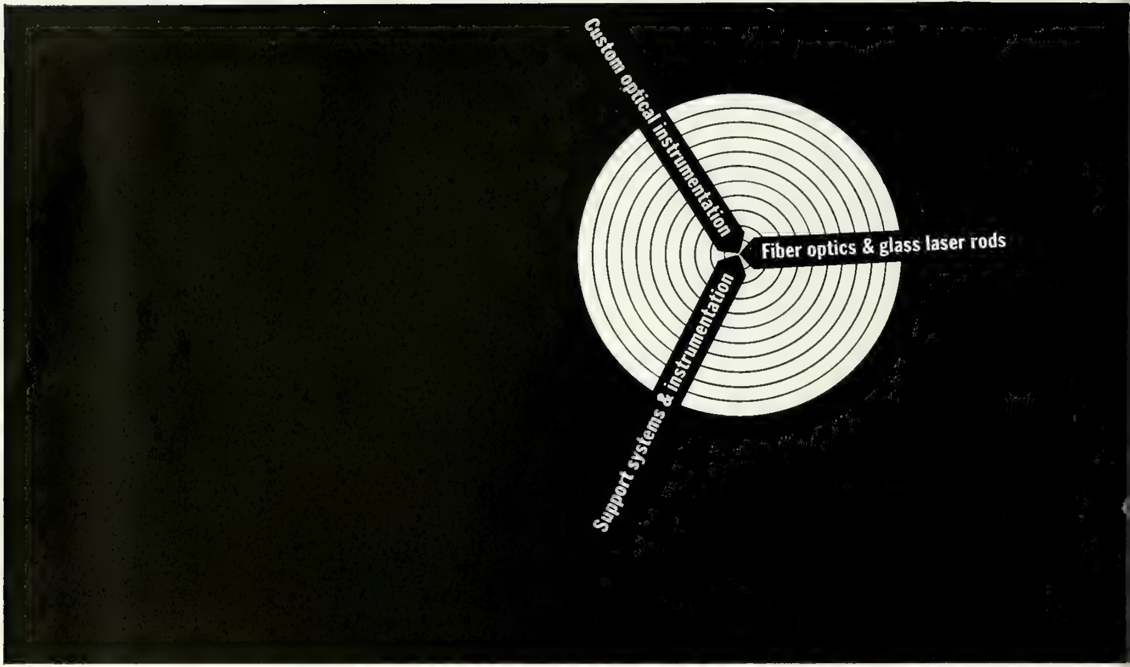
andrel for Aerojet-General's 260-in. Motor

oseidon Program To Cost $2 Billion . . . . . .

anned Gemini Flight May Come in April .

hiokol's Surveyor Engine Development . . .

It's our job to help you put light to work


Custom optical instrumentation
Fiber optics & glass laser rods
Support systems & instrumentation

Whenever or wherever you have to put light to work...to enslave it for any purpose...you're talking about the specialty of American Optical's Space-Defense Division. ● Our broad experience in precision optical and electro-mechanical-optical systems covers many areas: missile tracking and inertial guidance test equipment, lightweight optical components for space reconnaissance, target detection and fire control systems, fiber optics and neodymium glass laser rods. ● Over 1,000 sci tists, engineers and skilled craftsmen furnish a pool talents in the Space-Defense Division. From these, w draw the capabilities needed on a specific project, su port them with the most comprehensive manufacturi facilities. ● When you have a problem involving m terials, components, instruments or instrument system needed to put light to work, we're the people to see.

AMERICAN OPTICAL COMPAN
SPACE-DEFENSE DIVISION—SOUTHBRIDGE, MASSACHUSETTS

Circle No. 1 on Subscriber Service Card

nissiles and rockets

E WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 4 January 25, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors
arles D. LaFond................Electronics
lliam S. Beller................Engineering

Associate Editors
vrence J. Curran......Assistant Managing Editor
ther M. David..................Space Medicine
hael Getler.........................Electronics
sell Hawkes............................Industry
n F. Judge................Advanced Materials
ert L. Parker.......................Copy Editor
Pay..................................Electronics
Taylor...................................NASA
es Trainor...............................Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

drich Schonbach .... Art Director
ald Strickland...........Assistant Art Director
anne Montgomery...........Editorial Assistant
y Fosnight ....Editorial Assistant

EAUS
ANGELES ..9301 Wilshire Blvd., Beverly Hills
illard E. Wilks .... Bureau Chief
V YORK..................20 East 46th Street
ichael Getler
E KENNEDY ....507 Orange Ave.
hris Butler.....................Merritt Is., Fla.
WEST ....423 N. Quentin
hn L. Zimmerman ....Wichita, Kan.
IS..........................11 Rue Condorcet
an-Marie Riche
EVA.........................10 Rue Grenus
ank G. McGuire

ORIAL ADVISORY BOARD
Peter Castruccio Alexander Satin
ad H. Hoeppner Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

. Boughton............National Sales Manager
B. Kinney........Eastern Advertising Manager
n J. Denker, Jr.....Western Advertising Manager
eth C. Blanchard.Marketing & Research Director
N. Carlin..............Director of Circulation
ly Nelson...............Circulation Promotion
Virgil Parker.............Director of Production
ara Wiener........Advertising Services Manager

ished each Monday with the exception of the Monday in December by American Aviation ications, Inc., 1001 Vermont Ave., N.W., Washon, D.C. 20005. Cable Address: AMERAV.

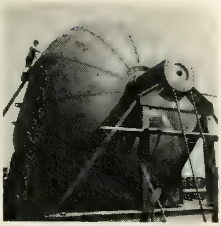
ted at Judd & Detweiler, Inc., Washington, D.C. nd class postage paid at Washington, D.C.

yright 1965, American Aviation Publications, Inc.

cription rates: U.S. and Possessions, Canada, and American Postal Union Nations: 1 year, $5.00, 2 s $8.00, 3 years $10.00. All other foreign: 1 year 00, 2 years $25.00, 3 years $35.00. Air freight to pe: 1 year $20.00, 2 years $30.00, 3 years $40.00. le copy prices: regular issues 50 cents each; ial issues $1.00 each. Subscriptions are solicited from persons with identifiable commercial or essional interests in the missile/space industry. cription orders and changes of address should be rred to Circulation Fulfillment Mgr., Missiles and ets, 1001 Vermont Ave., N.W., Washington, 20005. Allow 4 weeks for change to become ctive and enclose recent address label if possible.

ident.........................Wayne W. Parrish
or Vice President..............Louis C. James
President.........................Fred S. Hunter

THE COVER



Finishing touches are put on a 260-in.-dia. steel mandrel to be used by Aerojet-General Corp. to wind a glass filament rocket motor case for the Air Force big solids demonstration program. Mandrel was manufactured by Precision Fabricators, Inc., and must be removed after case is wound on its exterior.

JANUARY 25 HEADLINES

NASA Sets Feb. 8 as Launch Date for Second OSO 8
LBJ Defense Message Discloses $49-Billion Budget 10
Poseidon Expected to be Operational by 1970 12
DOD Funding Covers Short-Range Attack Missile 12
GT-2 Success Raises Hopes for April Manned Shot 13
Russian Fusion Research Ascendancy Detailed 14
Delta Facility To Allow West Coast Tiros Launches 15

SPACE PROPULSION

Surveyor Vernier Thrust Chamber Nears Completion .. 18
West German Students Develop New Throttle Method .. 27

MISSILE SUPPORT

Army Quest for Multi-System Tester Advances 22
Surplus Minutemen May Evaluate Guidance Systems .. 34

SPACE ELECTRONICS

Manned Spaceflight Control Center is Operational ... 24

SPACE SYSTEMS

Scanner Probe To Assist in Horizon Definition 31

DEPARTMENTS

Letters 4
The Countdown 7
The Missile/Space Week® 8
Technical Countdown .. 17
The Industry Week 37
Contracts/Procurements 38
Products & Processes ... 40
Names in the News ... 44
When & Where 45
Editorial 46

48,600 copies this issue

A Quick Step to "First Aid on Tap!"

When an accident occurs... step on the treadle for instant drenching. Wash contamination down the drain! See Haws Model 8600 decontamination station in the new "First Aid on Tap!" catalog today.

HAWS Since 1909

EMERGENCY DRENCH SHOWERS

HAWS DRINKING FAUCET CO.
1443 Fourth St. • Berkeley, Calif. 94710

Circle No. 2 on Subscriber Service Card

letters

MOL and More

To the Editor:

Your Dec. 14 editorial ("The *MOL* Decision") is excellent except for one critical point. It contains not a single word recognizing the military threat already posed by the fast-advancing Soviet manned space program.

Even in speculating on the possible benefits of *MOL* you mention only ". . . an effective missile defense, vastly improved reconnaissance capabilities, and perhaps a devastating offense." What about the capability of intercepting and eliminating offensive Soviet manned systems in space?

The debate and wishful thinking on whether the Soviets are competing in the Moon race has too long obscured the more fundamental question of why the Soviets are in space in the first place. Of course they'll go to the Moon! But only so long as it does not detract from their primary mission in space.

Their primary mission in space, as elsewhere, is now and always has been to rectify their preponderantly unfavorable strategic position *vis-à-vis* the United States. The Soviets are realists; their manned space activities are based on far more fundamental and tangible goals than mere national notoriety and a bucket of Moon dust.

Cuba demonstrated the scale of resources and boldness they will commit to their prime objectives. Only our good fortune in unmasking the Soviet missiles before they became operational saved us in that instance. If the Soviets succeed in fashioning a space-based system of strategic significance before we develop the capability of manned interception in space, history will write a bitter sequel to our idealistic commitment to peaceful space.

We have gone about attaining our stated goals in space in the worst possible fashion. We have taken vital resources from our armed forces and established a superfluous agency for the task, and all in the name of Peace. Even now that agency must run to catch up before it can begin to carry out its assigned mission. Witness the recent infusion of experienced Air Force personnel to replace "obsolescent" NASA types in Houston. Simply stated, NASA's Manned Space Flight Program is hardly more than the old German VfR grown bigger and bolder through a pipeline to the U.S. Treasury.

The real question at hand is not merely one of *MOL* versus *Apollo-X* but rather the more fundamental one of how we gear ourselves to meet the rapidly developing military mission in space. Do we install James E. Webb in the Pentagon or do we ship the Joint Chiefs to Houston? Where do we expect to get the cadres of technically proficient and operationally oriented personnel and the specialized hardware to meet this dawning challenge? Dare we resort to the solutions of 1940-41 with placards marked "interceptor" and broomsticks issued all around?

Certainly *MOL* should go forward! But *MOL* in itself is not nearly sufficient. Action must also be taken immediately to expand the objectives of *Gemini* in th vital areas of in-orbit maneuver and spa intercept. A thoroughgoing and coordinat program must also be initiated to pha NASA completely out of manned spa operations just as soon as practicable. R sponsibility for *Gemini* should be tran ferred to the Air Force immediately.

In the instance of *Apollo* we are in box, as you so forcefully pointed out your Oct. 19 editorial ("The Gauntlet" It is a box of our own making and i dimensions leave no alternative but to co tinue *Apollo* to its objective. But that h to be the end of the line for NASA.

By the time the Soviets reach the Moo whether just before or just after *Apoll* they will already have a long leg up o their primary mission in space. To wa until that time to begin a military spa program would be disastrous. The iss may very well have been decided by the

Frederick J. Howa
Freeport, N.Y.

Budget Rebuttal

To the Editor:

I have been under the impression th your magazine is of a serious nature a its columns devoted to those who hav an appreciation of the factors affecti our military posture.

In your Jan. 11 issue you publishe a letter by Mrs. Joan Cooper which a tempted in a very few brief sentences outline what is wrong with our milita budget.

1) Inspection trips by members of Co gress. Does Mrs. Cooper wish to de civilian supervision of our military activity While it is true there have been some e cesses here, the overwhelming majori of these trips are by dedicated Congressme trying to do their jobs. In addition, Secr tary McNamara has already taken ste to limit traveling by our elected represent tives on military aircraft.

2) The welfare programs. Where shou they be cut? In old-age assistance pr grams? In the children's milk fund?

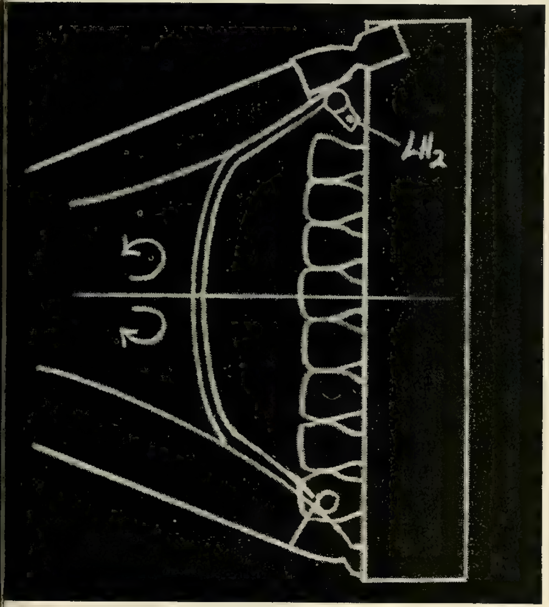
3) The cost of foreign aid—to bo non-communist and communist countrie Mrs. Cooper's letter indicates that she b lieves President Johnson and Secretari Rusk and McNamara are unaware of wh they are doing. It should also be noted th roughly half of foreign aid goes towa providing military assistance for our allie Our world-wide commitments can be m in this way much less expensively tha by stationing U.S. troops throughout t world. Furthermore, the aid given to ce tain communist countries is designed further U.S. interests, not those of Mosco

May I recommend that Mrs. Coop put a little more faith in our elected o ficials, and a little less in literature whic sees treason and cupidity in our forei aid program. A look behind the surfa is often much more revealing than t surface itself.

Benjamin Duh
New York, N.

IGHLY QUALIFIED ROPULSION ENGINEERS

VORK ON PROBLEMS IKE THIS...



n annular cluster of engines is used to form a truncated ug nozzle. How do we provide efficient cooling of the ug under varying engine conditions and during engine-st re-entry from orbit?

WITH ASSOCIATES LIKE THESE...

R. H. Michaelis is currently responsible for propulsion system design and analysis for advanced launch vehicles. Previous assignments include studies of manned lunar landings, orbital propellant storage, and high energy upper stages; the design of various Saturn S-IV propulsion subsystems; and the deployment of Thor IRBMs in England.

Mrs. M. L. Williams is presently conducting research on advanced propellants and combustion. Her background includes 13 years of experience with U.S. Naval Ordnance in the fields of physical chemistry, propellant process development, and propellant research. She is a member of ReSA, an Associate Fellow of AIAA and the author of many technical papers.

..IN THIS PROFESSIONAL TMOSPHERE

he Douglas Advance Space Technology Department is professional community charged with the responsibility evolving new concepts for the nation's space program. It combines research and advance design functions in self-administered unit having the atmosphere of a small, ighly qualified engineering organization. But it also has e advantage of having at hand the vast support functions nd facilities of a major aerospace company. Its studies e tempered by the scientific critique of its research groups nd the realism required by the knowledge that eventually hardware" end products are involved.

N INVITATION. Key openings are now available in the Propulsion Branch for qualified professionals with experience and/or advanced degrees, in all areas of rocket propulsion; i.e., chemical, nuclear and electric. We invite you to look into them by writing (please include resume) to the following address:

Mr. F. S. Snodgrass

DOUGLAS

MISSILE & SPACE SYSTEMS DIVISION
2720 Ocean Park Boulevard, Santa Monica, California
An equal opportunity employer

This is DEI's Solid State Receiver

It's new
Tunes in the range of 100 to 2300 mc
Superior performance characteristics
The TR-711 is virtually spurious free
Sets the standard for comparison

SWEEP WIDTH
MARKER
GAIN
FREQUENCY
TUNING
FIRST LO MODE
AM/FM DEMODULATOR
IF BANDWIDTH
SELECTOR
IF BANDWIDTH
DEI
VIDEO
VIDEO FILTER BANDWIDTH
AUDIO GAIN
SIGNAL LEVEL ZERO ON NOISE
SECOND LO MODE

The TR-711 Receiver is modular in construction and can be supplied with a complete complement of plug-in modules including RF tuning units from 100 to 2300 mc, IF amplifiers with 10 kc to 3.3 mc bandwidths, AM, FM, and phase demodulators, and plug-in spectrum display unit, oscilloscope, predetection up and down converter, or high capture ratio discriminator. Any combination of plug-in modules can be utilized, thus providing unlimited receiving combinations adaptable to any known or projected telemetry system.

Characteristics and accessories are described in Bulletin TR-711.

Defense Electronics, Inc.
Rockville, Maryland

DEI
RESEARCH
DEVELOPMENT
MANUFACTURING

ROCKVILLE, MD. (301) 762-5700, TWX: 301-427-4660; **SHERMAN OAKS, CALIF.** (213) 872-2870, TWX: 213-732-2742; **COCOA, FLA.** (305) 632-5442; INT'L., **ROCKVILLE, MARYLAND.**

Circle No. 18 on Subscriber Service Card

The Countdown

WASHINGTON

oseidon Answer to Soviets?

Back when *Poseidon* was the *Polaris B-3*, industry offiials told M/R that the decision on developing a *B-3* would epend on what the Soviets developed in the anti-missile field. n other words, if the Defense Dept. felt that the Russian nti-missile system was fairly effective, the *B-3* would be iven a go-ahead. Question now is: What exactly have the oviets developed? Rear Adm. Levering Smith, technical diector of the Navy's Special Projects Office, said recently at "the earliest" time he expects the system to be operaonal is "something like 1969 or 1970," but he didn't expect would be needed that soon because "there aren't the indiations of that kind of progress by the Russians."

oseidon To Feed Minuteman II

Improvements expected in the propulsion system of *oseidon,* as well as guidance improvements, are to be fed nto the product improvement program of *Minuteman II,* an dministration official says. Advanced penetration aids are lso expected to provide valuable inputs for the land-based CBM.

ooster Hearings Slated This Week

Senate Space Committee will hold its long-awaited briefngs on the Air Force and NASA booster programs Jan. 26 nd 27. Deputy Secretary of Defense Cyrus Vance and ASA Administrator James E. Webb will testify, and will e accompanied by Dr. Harold Brown, Director of Defense esearch and Engineering, and Dr. Robert Seamans, NASA ssociate administrator. The committee will decide later hether additional hearings are necessary.

ASA To Control New Delta Pad

NASA and DOD are expected soon to announce agreeent on construction of a *Delta* launch pad at Western Test perations. The space agency is expected to get control of unches from the pad, which will be built with NASA oney. In addition to *TIROS* launches, another spacecraft at could be put into polar orbit from the facility is the *iosatellite.*

ike-X: Chiefs-Yea, Mc-Nay

Joint Chiefs of Staff voted unanimously to include prouction money in the Fiscal Year 1966 budget for *Nike-X.* ecretary McNamara felt any such decision should await sysems tests coming up late this year and early next. He arried the day with the President, and the decision has een postponed.

pace Agency Centralizes R&D Planning

NASA's Office of Advanced Research & Technology is stablishing a Future Missions Division, to be located at mes Research Center. Staffed by 50 engineers, its job will e to plan and define the space agency's future research and evelopment programs. Staff will mainly be personnel transerred from all other NASA research centers.

cientist/Astronauts Being Screened

Some 1,500 applications have been received from hopeful cientist/astronaut candidates. NASA expects about 25% to meet the minimum standards. In about two weeks, Manned Spacecraft Center will send the list of qualified candidates to NASA headquarters and the National Academy of Sciences for their review. It's expected that about 50 will be selected on the initial list; this will later be trimmed to the announced 10-20-man total for the new astronaut group.

Legislation To Aid Oceanographers

Groundwork is fast being laid for expansion of oceanographic research. Senate Commerce Committee is considering a bill that would create a new category of marine law for ships carrying scientific personnel, thus freeing them from restrictions applicable to passenger and cargo vessels. Such ships could be operated by universities, industry firms, or marine laboratories.

Manned and Unmanned Advocates at Odds

A problem reported to be mounting in NASA is a divergence in aims and attitudes of those working on manned spaceflight and those involved in unmanned space exploration. Some agency sources say this has created a management division within NASA that needs reorienting to better integrate the space program. They see the unmanned space effort failing to support manned exploration with needed missions, thereby holding up logical and timely progression of the manned program.

INDUSTRY

Douglas Delivers A-ICBM Study

Douglas Missile & Space Systems Div. has completed a seven-month study of the "Characteristics of Anti-Ballistic Missile Systems Optimized for Defense Against Small Attacks," under contract with the Pentagon's Advanced Research Projects Agency, which is showing increasing interest in such limited anti-missile concepts (M/R, Jan. 18, p. 13). The solicited study sought to identify salient design features, deployment options, cost and effectiveness of systems that might be employed against specified "small attacks."

Awards Near on X-15 Ramjet Design

NASA expects to award contracts late this month or early in February for design of an experimental ramjet engine that eventually will be flown on the *X-15* No. 2 rocket plane. Evaluation of proposals by four firms—Garrett Corp., Marquardt, General Electric and Pratt & Whitney—is being conducted at the Langley Research Center. Three of the firms are expected to be picked for parallel work. Later, one will be chosen to actually build the flight engine.

INTERNATIONAL

Fatal Soviet Launches Reported

A number of Russian cosmonauts reportedly have died due to booster failures at launch, a U.S. scientist told M/R. Dr. A. J. Drummond of Eppley Laboratory, Newport, R. I., said he got this information through unofficial sources while attending a technical meeting in Leningrad last year. He also said there were no large solar-simulation testing facilities in the Soviet Union, and Russian spacecraft use crude bulk insulation for thermal control instead of emission-absorption coatings.

The Missile/Space Week

OSO-B2 Launch Set

Another attempt to launch the second *Orbiting Solar Observatory* (*OSO-B2*) will be made by NASA Feb. 8.

The 545-lb. scientific satellite is made up primarily of parts salvaged from the *OSO-B*, damaged April 14 in a pre-launch mishap, and components of a spacecraft prototype. If it achieves orbit, it will be called *OSO-II*.

The scientific payload, although similar to the first solar observatory, will include experiments for more extensive scientific investigations of the Sun than those carried on *OSO-I*, launched Mar. 7, 1962. The eight experiments on *OSO-B2* will account for 215 lbs. of the total weight.

OSO-B was to have been launched in April, 1964. However, during prelaunch checkout, the satellite was seriously damaged when the X-248 third stage rocket to which it was mated inadvertently ignited. Three technicians were fatally burned.

OSO-B2 will be launched from Cape Kennedy by a three-stage *Delta* into a circular orbit at 350 mi. altitude. Inclination will be 33 degrees; period will be about 95 minutes. Operational lifetime is expected to be about six months.

The satellite has two main sections. The spinning base portion, called the wheel, will house telemetry, command, control electronics and five experiments. The fan-shaped sail, or top section, will point toward the Sun when it is visible. It contains two primary solar pointing experiment packages, containing three experiments.

For the first time, the satellite will use the raster scan mode of operation. With this method, instruments controlled by ground command will scan the entire solar surface, requiring four minutes for each scan.

Electric Voyager Engines Seen

NASA and the Air Force have been discussing the possibility of using electric propulsion devices for continuous power on the *Voyager* Mars fly-by mission.

The application is under consideration for the 1971 orbiter/lander or the 1969 fly-by trial run as the first major electric engine application. The concept is being discussed by the Aerospace Power Div., Aero Propulsion Lab of the Air Force Research and Technology Div. and NASA's Lewis Research Center.

The feasibility of such an approach will be determined in about a year. There is nothing definite in sight and the particular electric engine configuration has not been determined.

Arms Control Agency Extended

President Johnson has asked Congress to extend the life of the Arms Control and Disarmament Agency for four years. Present authorization for the disarmament group expires June 30, 1965.

In a brief special message, the President expressed himself as "determined to work in every way . . . for safeguarded agreements that will halt the spread of nuclear weapons, lessen the risk of war and reduce the dangers and costly burdens of armaments." No specific proposals to achieve these goals were outlined in the message.

A bill to extend the agency for four more years accompanied the President's letter and called for the agency to have a total budget over this time period of $55 million. The FY '65 budget of the Arms Control Agency is $9 million. In FY '66, the President is expected to ask slightly more.

Shots of the Week

NASA successfully launched *Titan/Gemini-2* from Cape Kennedy on Jan. 19 (see p. 13).

- The Air Force launched the four-stage *Athena* re-entry research vehicle from Green River, Utah, Jan. 15. The flight was termed "flawless" and impacted within a predetermined target area in the White Sands Missile Range, N.M.
- An Air Force Strategic Air Command crew successfully launched a *Titan I* ICBM from Vandenberg, AFB, Calif., on Jan. 14.

Republic Gets New Exec

A former Fairchild Hiller Corp. executive has been named executive vice president of Republic Aviation, a firm Fairchild Hiller intends to take over this year.

Charles Collis resigned from his post as vice president-subsystems group at Fairchild Hiller and wil assume day-to-day direction of Republic, which has been run by a four man management team since las summer, when Fairchild Hiller interest in the Long Island aircraf concern was established.

Fairchild Hiller president Edward G. Uhl claims his firm ca now "count on" more than 700,00 of Republic's 2.8 million shares o stock, and says that absorption o the Long Island aircraft concern wi be completed "sometime this year. When the final merger is worked ou Republic stands to lose its identity a a separate function and, thus, wi not continue as a subsidiary. Rathe Republic activities would be blende with compatible activities in Fairchild Hiller.

Meantime, eight Republic vic presidents have been released. Onl two, engineering vice president Joh Stack and Murry Berkow of aerospace systems and service, remai

Interim Isotope Engine Possibl

Snapoodle, a combination of a auxiliary electric power unit wit the Poodle isotope-powered space engine, could be developed in thre years to fill the so-called "SNAP gap

The concept, being developed b the Air Force at Wright-Patterso AFB, Ohio, in conjunction with th Atomic Energy Commission is miniature *Rover* capable of operati 90 days with a core of polonium 21

Snapoodle provides simultaneou generation of both electrical pow and thrust. Air Force researche say the system is attractive for spa missions involving propulsion as prime requisite and electrical pow is needed only for short periods the end of powered flight when us with energy storage units.

The system is an ideal answer those instances demanding contin ous low level electronic power in a dition to the propulsion requireme The work is being done at Air For Systems Command's Research a Technology Division's Aero Prop sion Laboratory.

Committee Assignments List

Committee assignments for bo parties have been made in bo Houses of Congress. New membe on the Senate Space Committee a Walter F. Mondale (D-Minn.), ɘph Tydings (D-Md.), Len B. Joran (R-Ida.), and George D. Aiken R-Vt.)

Senate Armed Services: Thomas [cIntyre (D-N.H.), Daniel Brewɛer (D-Md.), Jack Miller (R-Iowa), ɔhn G. Tower (R-Tex.). Appropriaons: Ralph Yarborough (D-Tex.).

House Armed Services: Alton ennon (D-N.C.), William J. Ranall (D-Mo.), G. Elliott Hagan (Da.), Chas. Wilson (D-Calif.), Robert . Leggett (D-Calif.), Donald J. Irwin D-Conn.), Jed Johnson, Jr. (Dkla.), Frank E. Evans (D-Colo.), odney M. Love (D-Ohio), Floyd V. icks (D-Wash.), Hervey G. Machen D-Md.), Speedy O. Long (D-La.), nd E. S. Johnny Walker (D-N.M.).

House Science and Astronautics: oy A. Taylor (D-N.C.), George E. rown, Jr. (D-Calif.), Walter H. oeller (D-Ohio), William R. Anerson (D-Tenn.), Brock Adams (Dash.), Lester L. Wolff (D-N.Y.), eston E. Vivian (D-Mich.), Gale chisler (D-Ill.), and Barber B. Conble, Jr. (R-N.Y.).

House Appropriations: W. R. ull, Jr. (D-Mo.), D. R. Matthews D-Fla.), J. Cohelan (D-Calif.), T. . Morris (D-N.M.), E. J. Patten (D-.J.), C. D. Long (D-Md.), J. O. arsh, Jr. (D-Va.), R. B. Duncan D-Ore.), S. R. Yates (D-Ill.), Billie Farnum (D-Mich.), Glenn R. avis (R-Wis.), Howard W. Robion (R-N.Y.), Garner E. Shriver (Ran.), Joseph M. McDade (R-Pa.), ark Andrews (R-N.D.).

aytheon Gets Sonar Contract

The Navy Bureau of Ships has warded the Raytheon Co. an $18.5-illion contract for submarine sonar ystems. The pact, termed the "largɛt single contract ever awarded for onar for nuclear attack submanes," covers additional engineering nd production of the sonar as well training and testing by Raytheon's ubmarine Signal Div. at Portsouth, R.I.

ASA Studies College Research

An evaluation of NASA-suported university research will be onducted Mar. 1-3 at the NASAniversity Program Review Conɛrence in Kansas City, Mo.

The meeting will take a hard look what has been accomplished by e 200 universities and colleges parcipating in programs. The space gency will also examine the potenal for further work and attempt to quaint non-participating univerties with NASA efforts in the area university research.

Circle No. 3 on Subscriber Service Card→

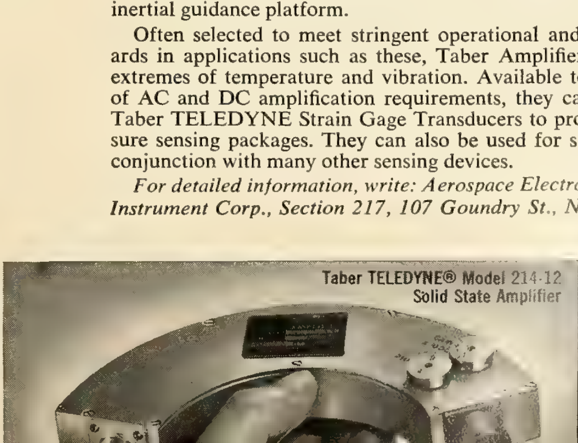
Taber Teledyne® Amplifier built into Polaris fire control by G.E.

Developed by the Navy and General Electric, Mk 84 Fire Control Systems receive, interpret and transmit essential position, flight and target data for rapid-rate firing of Polaris missiles in ranges up to 2500 nautical miles. Shown above is the supervisor's console aboard the U.S.S. Lafayette from which the entire operation of the Mk 84 System is monitored and controlled.

Serving as a pre-amp in an electro-mechanical resolver servo, Taber TELEDYNE® Model 214-12 Solid State Amplifier is part of the inductosyn servo used by the Fire Control System in fine alignment of the inertial guidance platform.

Often selected to meet stringent operational and maintenance standards in applications such as these, Taber Amplifiers are reliable under extremes of temperature and vibration. Available to meet a wide range of AC and DC amplification requirements, they can be combined with Taber TELEDYNE Strain Gage Transducers to provide high level pressure sensing packages. They can also be used for signal conditioning in conjunction with many other sensing devices.

For detailed information, write: Aerospace Electronics Division, Taber Instrument Corp., Section 217, 107 Goundry St., N. Tonawanda, N. Y.



Taber

Formerly Polaris B-3 . . .

Poseidon Has $2-Billion Price Tag

Navy weapon, Short Range Attack Missile, penetration aids for strategic missiles singled out in LBJ defense message

by James Trainor

DEVELOPMENT and production of the *Polaris B-3*—now called *Poseidon* by the Defense Department—will cost $2 billion. Of this sum, $800 million will be spent on development of the new missile and $1.2 billion on production and modification of *Polaris* submarines to accept the underwater-launched strategic weapon.

Named after the Greek god of the sea, *Poseidon* will have double the payload of the highly successful *Polaris A-3*, President Johnson told Congress in a special message on Defense Jan. 18. He said the increased accuracy and flexibility of the *Poseidon* will permit its use against a broader range of targets and give added insurance of penetration of enemy defenses.

SRAM, the *Short Range Attack Missile,* was also listed as one of the "major new developments in strategic weapons systems" that will be started with FY '66 funds. The qualifying phrase in this announcement, however, was that the missile can, "if needed," be deployed operationally on strategic aircraft.

Also singled out for attention in the message was the initiation of "a series of remarkable new payloads for strategic missiles," including penetration aids to insure that the missile reaches its target through any defense, guidance and re-entry vehicle designs "to increase many-fold the effectiveness of our missiles against various kinds of targets" and methods of reporting the "arrival of our missiles on target, up to and even including the time of explosion."

• **Overall budget down**—In spite of these new programs, however, the Fiscal 1966 Defense expenditures are to decline to $49.0 billion, the President told Congress. This is $2 billion less than the new spending authority asked in the FY '64 budget and $300 million less than the estimated expenditures in the current Fiscal Year—$49.3 billion. The new obligational authority requested in FY '65 was $50.9 billion.

President Johnson gave two main reasons for this leveling off of spending:

—Achievement of many of the needed changes and increases in the military force structure;

—Realization of the benefits of the cost reduction program introduced into the Defense establishment during the past four years.

Asserting the credibility, flexibility and worth of American power across the spectrum of warfare, the President emphasized that barring a significant shift in the international situation, the U.S. is not likely to require further increments to its defense budget during the next several years.

Thus, defense is expected to take a declining share of the Gross National Product, now growing at a rate of five percent per year.

• **Nike-X "tabled"**—One of the defense needs that has been postponed is the decision to place the *Nike-X* anti-missile system into production. The Army weapon will continue for at least another year in development. A high administration official estimated that the FY '66 funding level for *Nike-X* would be $400 million, with another $100 million earmarked for Project Defender.

"Our investment has effected an enormous improvement in the design of anti-ballistic missile systems," the President said. "We will pursue our program for the development of the *Nike-X* anti-missile system, to permit deployment of this anti-ballistic missile should the national security require. Research will continue on even more advanced anti-missile components and concepts."

The President and the high administration official who discussed the message with reporters emphasized the importance of fallout shelters as the *sine qua non* of a defensive system. Both in terms of the money required and the number of lives saved, shelters were said to have clear value without other systems. The administration official termed "absurd" the deployment of a missile defense system without a civilian shelter program.

While expressing confidence that the present U.S. strength was sufficient t deter a nuclear war, the President thu reaffirmed his intention to "always b alert" to possibilities of limiting destruction in the event deterrence fails, bu added that any comprehensive program would cost tens of billions of dollars.

"We shall continue the research an development which retains the option to deploy an anti-ballistic missile system and manned interceptors and surface-to air missiles against bombers," the President pledged.

• **RDT&E value recognized**—In addition to development of specific weapons systems, about $2 billion a year ou of the total RDT&E budget of $6 billion is invested in innovations in technology and in experimental programs the message noted. "Thus we provid full play for the ingenuity and inventiveness of the best scientific and technica talent in our nation and the free world American science, industry and technology are foremost in the world. Thei resources represent a prime asset to ou national security."

One of the more terse statements i the President's message, but one likel to cause some controversy, was that th Secretary of Defense would presen some recommendations to strengthe the Joint Staff. Secretary Robert S. Mc Namara later the same day sent a lette to Congress asking that the Joint Staf be doubled in size from a statutory limi of 400 officers to 800. He also aske that the Director of the Joint Staff b made a four-star general—equal in ran but subordinate to the Joint Chiefs o Staff.

Congress has, in the past, oppose building a strong Joint staff and enhancing the power of its director. Thi would eventually create a single chie of staff, some members of Congres fear.

After noting that the U.S. has mor than 850 land-based intercontinenta ballistic missiles, more than 300 nuclear armed missiles in *Polaris* submarine and more than 900 strategic bombers half of them ready at all times to be airborne within 15 minutes, the President's message stresses maintenance of this uperiority.

"The immediate future will see furher increases in our missile strength, as well as concentration on further technological improvements and continuing igorous research and development."

• Economical management stressed —President Johnson stressed the importance of economy and sound management to the maintenance of U.S. superiority. He backed the McNamara policy of replacing outmoded weapons with new ones and eliminating obsolete quipment and installations as well as costly duplication of effort. "We are following this policy now, and so long as am President, I intend to continue to follow this policy," Johnson said.

As part of this continuing process of renewal, the President said that these changes were being made in the strategic forces combination in the next year:

—Requesting more than $300 million to continue the program for extending the life and improving the capabilities of B-52 strategic bombers while eliminating two squadrons of B-52Bs, the earliest—and least effective —model of this plane.

—Continuing development of engines and other systems for advanced aircraft to retain the option for a new manned bomber, should the need arise.

—Continuing deployment of the SR-71, the world's fastest airplane, which will enter the active forces this year.

—Continuing installation of the new over-the-horizon radars, giving the U.S. almost instantaneous knowledge of ballistic missiles launched for attack.

—Continuing procurement and deployment of the latest operational strategic missiles, *Minuteman II* and *Polaris A-3*, greatly extending the range, accuracy and striking power of the strategic forces.

—Replacing older, more costly, and vulnerable elements of strategic forces. The out-dated *Atlas* and *Titan I* missiles will be retired this year and the remainder of the B-47 forces will be phased out during Fiscal Year 1966.

As control elements of this force, the President announced that the U.S. had developed and procured the Post Attack Command and Control System of the Strategic Air Command to assure continued control of strategic forces after a nuclear attack. He also emphasized the new precautions that have been installed to guarantee that nuclear weapons are not used except at the direction of the highest national authority.

In Fiscal 1966, the President noted, funds also will be requested to extend similar improvements in the survivability and effectiveness of C&C to other commands in overseas areas. ■

Defense Message Highlights

Following are excerpts from President Lyndon B. Johnson's Message to the Congress on defense:

Today we can walk the road of peace because we have the strength we need. We have built that strength with courage. We have employed it with care. We have maintained it with conviction that the reward of our resolution will be peace and freedom.

Our forces are balanced and ready, mobile and diverse. Our allies trust our strength and our adversaries respect it. But the challenge is unceasing. The forms of conflict become more subtle and more complex every day. We must—and we shall—adapt our forces and our tactics to fulfill our purposes.

We must further improve our ability to concentrate our power rapidly in a threatened area, so as to halt aggression early and swiftly. We plan expansion of our airlift, improvement of our sealift, and more prepositioned equipment to enable us to move our troops overseas in a matter of days, rather than weeks.

To this end, we will . . . Begin large-scale procurement of the revolutionary swept wing F-111 and the new A-7 Navy attack aircraft.

We will also begin construction of four new nuclear-powered attack submarines, and ten new destroyer escorts. And we will continue to develop a much smaller, more efficient nuclear power plant for possible use in our future aircraft carriers.

We have made dramatic improvements in our ability to communicate with and command our forces, both at the national level and at the level of the theatre commanders. We have established a National Military Command System, with the most advanced electronic and communications equipment, to gather and present the military information necessary for top level management of crises to assure the continuity of control through all levels of command. Its survival under attack is insured by a system of airborne, shipborne and other command posts, and a variety of alternative protected communications.

The North Atlantic Treaty Organization is a strong shield against aggression. We reaffirm our belief in the necessity of unified planning and execution of strategy. We invite our NATO allies to work with us in developing better methods for mutual consultation and joint strategic study. We shall continue to seek ways to bind the alliance even more strongly together by sharing the tasks of defense through collective action.

We will continue to help local communities by mobilizing and coordinating all the resources of the Federal Government to overcome temporary difficulties created by the curtailment of any defense activity. We will phase out unnecessary defense operations in such a way as to lessen the impact on any community, and we will work with local communities to develop energetic programs of self-help, calling on the resources of state and local governments—and of private industry—as well as those of the Federal Government.

The experience of several years has shown that certain activities of the Defense establishment can be conducted not only with greater economy, but far more effectively when carried out on a Department-wide basis, either by a military department as executive agent or by a defense agency. . . Most important, these actions are informing and expediting the decision-making process. We will continue to seek out opportunities to further increase the effectiveness and efficiency of our Defense establishment.

Poseidon a 'Further Developed' B-3

System with twice the accuracy and payload of Polaris A-3 will be operational by 1970; Lockheed remains systems contractor

ADMINISTRATION officials found themselves on the horns of a dilemma in explaining the difference between the "new" *Poseidon* missile and the *Polaris B-3*.

It now appears that the two are the same but that the name has been changed to avoid "semantic confusion," in the words of one high-level Administration spokesman. Also, this official said that since the Dept. of Defense had never gone to Congress and asked for money to develop the *B-3* missile, the *Polaris B-3* program never really existed.

There was $5 million in the Fiscal Year 1965 budget, however, for program definition of the *B-3*. Furthermore, during the last several weeks this magazine has reported, and the Navy has verified, that a contract will be awarded soon for Program Definition of the *B-3*. Presumably, the contract will now be awarded for the Program Definition Phase of *Poseidon*.

● **A lesson learned**—In the 1964 Presidential campaign, Sen. Barry Goldwater and a Republican Task Force on Defense chided the Administration for failure to develop new strategic systems. In reply, DOD cited the *Minuteman II* as a new missile—as different from the *Minuteman I* as the B-52 is from the B-47.

However, because the two missiles carried the same name the point was never firmly made. Republicans chortled that the Democrats were parading modifications to old systems and calling them completely new weapons.

It is to avoid this type of "semantic confusion" that the *B-3* designation for the advanced *Polaris* has been dropped and a new designation, *Poseidon* adopted. The new name is that of th god of the sea, in Greek mythology.

● **Then, what is it?**—The Administration official termed the *Poseidon* "significantly larger" than presently operational *Polaris* missiles. Initially, he als denied that this was the *B-3* concept He later admitted that the missile h was describing is the same as the *B-* Lockheed and the Navy postulate.

Poseidon, he said, was a "furthe development of *B-3* objectives." It woul have twice the accuracy and carry twic the payload of the *Polaris A-3*. Th *A-3* has a range of 2,500 n. mi. (2,88 statute miles) and carries a 700-800-k nuclear warhead. It also has a sophisticated penetration aids package. Th doubled accuracy of the *Poseidon* i comparison with the *A-3* gives an eightfold increase in effect on the target, sinc effect varies as the cube of accuracy

The new missile, according to thi official, would have the same range a the *A-3*. However, with twice the payload, it does not follow that the warhea size would be increased.

The official refused to estimate whe *Poseidon* would be operational. But industry sources have estimated that, eve with the PDP, the missile would be i the Fleet by 1970.

The missile will be deployed in present *Polaris* submarines. In fact, earlie this year when Defense officials wer testifying before Congress they justifie the maintaining of Fleet Ballistic Missile submarines 6-18 with the *A-2* o the basis that, if the *B-3* was developed a number of these subs would be retrofitted with the missile. A mixed force o *A-3* and *Poseidon* missiles is therefor envisaged in the 1970's with perhap as many as 192 *Poseidon* missiles.

Components for the *Poseidon* hav been under development for two o three years, the spokesman said.

Whether the missile is called *Poseidon* or *Polaris B-3,* Lockheed will stil be designated the systems contractor However, the propulsion, guidance an ancillary equipment is to be put ou for competition. ■

SRAM Will Afford Stand-Off Capability

SRAM, the *Short-Range Attack Missile* for the B-52 or other bombers, will enable the aircraft to attack "a far larger number of targets and to do so from beyond the range of their local defenses."

The President's defense message also called the "aerodynamic" missile "a vast improvement over existing systems." However, a high Administration official stressed the qualifying phrase in the President's message that the system would be deployed only "if needed."

"We are not certain that *SRAM* will be needed," he said, "and we are undertaking the development because it might be needed." He added that the missile would allow the B-52 to stay out of the cone of fire of local air defenses. He did not discuss this stand-off capability in relation to the statement that the bomber would be able to take under fire "a far larger" number of targets.

Range of the weapon was revealed as about 100 miles, or "one-tenth the range of *Skybolt.*" Also, the accuracy of the *SRAM,* the spokesman said, is a "very, very small number of feet." This means that the system will employ a terminal guidance device—probably either a target mosaic matching system or a TV-contrast system as employed in the Navy's "eye" series of weapons.

Under questioning, the official admitted that the F-111 "possibly" could carry the *SRAM.*

RFP's for Phase 1A of Program Definition are expected to be issued early this calendar year. Development is not expected to begin until the first part of 1966.

Use of the word "aerodynamic" in describing the missile has led some observers to conclude that this missile is winged. The actual intent, it appears, is to distinguish it from *Skybolt. SRAM* will not be a ballistic missile which leaves the atmosphere but rather will be launched toward the target and will maneuver entirely within the atmosphere. ■

NASA buoyed by GT-2 . . .

Manned Gemini Flight Set for April

Near-perfect ballistic shot marred by 25-sec. loss of communications; agency still hoping to get off four manned flights before end of 1965

THE SPACE AGENCY has given he go-ahead for a manned *Gemini* flight n April as a result of the successful unmanned ballistic shot last week.

Chris Kraft, flight director for the *Gemini/Titan-2 (GT-2)* flight on Jan. 9, declared that "we plan to go ahead with the *GT-3* mission within three months." Other officials said that earliest launch date for the two-man three-orbital flight was April, but slippage into May or later is possible.

The 7,000-lb. *Gemini* capsule was recovered about 2,125 miles downrange in the Atlantic Ocean following the launch from Cape Kennedy. The capsule and its *Titan II* booster reached an altitude of 96.9 mi. during the 19-minute ight before arching over and diving ack into the Earth's atmosphere at a speed of 25,779 ft. per sec.

The official launch time was 9:03 .m. EST. Touchdown came at 9:22 .m. Final flight performance figures will ot be available for about a week.

The flight apparently was almost awless. Kraft said that judging from isual appearances operation of all systems seemed to be nominal.

There was one minor discrepancy in the mission. The actual impact point was some 25 miles short of the planned spot. This was blamed on a negative ight path angle of 2.48 degrees, compared to the nominal 2.28 degrees. The top altitude of 96.9 statute miles was lso short of the desired 99.68 miles.

No guess was made as to the cause f the discrepancy pending study of data ransmitted from the capsule.

Kraft did say that while the perormance of the *Gemini/Titan II* launch ehicle combination was well within afety standards for a manned flight, "We hope to do better in our upcoming missions."

The *GT-2* capsule was plucked from he ocean by the carrier Lake Champain. It was returned to Cape Kennedy, where it will be inspected, studied and hen completely dismantled to gather nformation for the next manned flight.

The spacecraft contained two "astrorobots," so-called crewman simulators with batteries for hearts, cameras for eyes, sensors for fingers and sequences and timers for brains and nerves.

The *GT-2* flight was first scheduled for Dec. 9, but it was postponed when an actuator in the hydraulic system sheered off.

- **Blackout**—One major problem which cropped up during the mission was not connected with either the capsule or the launch vehicle.

A power failure in the *Gemini* control center at Cape Kennedy forced flight operation engineers to lose communications with the spacecraft for some 25 seconds. The officials said they did not know what caused the failure, which occurred when an electrical overload blew a circuit breaker. They said that while the control center has a backup power system, it is not truly redundant because they both operate off the same circuit breaker.

While the failure did not affect the *GT-2* mission, a similar occurrence during a manned mission could have serious consequences. This would be especially true if communications were lost while an astronaut was receiving emergency instructions to enable him to correct a spacecraft malfunction.

The power loss marked the first time that such a failure had occurred. Officials said it had to be regarded as a serious problem.

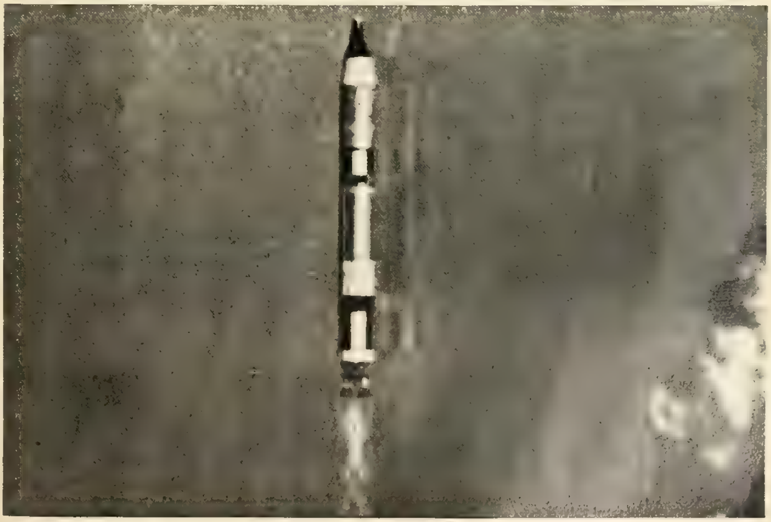
- **Slippage**—Despite the *GT-2* success, the *Gemini* program is still limping along, about two and one half years behind schedule and at a cost of $1.3 billion, more than twice the $600 million estimated when the project was initiated.

The two astronauts who will ride the *Gemini* capsule on the first manned flight—Virgil I. (Gus) Grissom and John W. Young—were eyewitnesses to last week's launch.

The space agency still plans to conduct four manned flights in 1965, but this appears to be unlikely. Following *GT-3*, other planned flights will last four days, seven days and two days respectively.

The two-day trip will be the first rendezvous mission with the *Agena D* stage. ■

GEMINI/TITAN-2 lifts off from Cape Kennedy at 9:03 a.m. EST Jan. 19 to start successful 19-minute, 2,125-mi. flight downrange over Atlantic Ocean.



U.S. expert declares . . .

Soviets Leading in Fusion Research

Russians spend five times as much as U.S. on controlled fusion work; U.S. scientists report on three new milestones

by Warren Burkett

San Diego—A leading U.S. scientist declares that the Soviet Union is now ahead of the United States in controlled nuclear fusion research.

Dr. William E. Drummond, a theoretical physicist for the General Atomic Division of General Dynamics, also says the Russians are spending $60 million per year on their research program—about five times the current U.S. effort.

"We are learning more from them than they are from us," he continued.

Dr. Drummond and Dr. Marshall N. Rosenbluth, chief theoretical physicist at the division and 1964 winner of the Ernest O. Lawrence Memorial Award from the Atomic Energy Commission for his "highly original" contributions to atomic energy research, spent much of their time in 1964 observing the Russian program and conferring with Russian plasma physicists.

Rosenbluth toured all the Russian fusion research centers on an AEC exchance visit, and, with Drummond, helped open the new International Center for Theoretical Physics in Trieste last fall.

He says the technology that will permit controlled nuclear fusion for power generation probably lies 20 years ahead, although some optimists expect to achieve it in 10 years.

"We have survived the optimism of 1958-59 and the period of depression in 1960 and 1961 when physicists realized how difficult the job would be. Scientists have abandoned the idea that you could achieve fusion through brute force in favor of more basic science in the understanding of plasma physics," he said.

Both scientists said that Russia attaches a priority to fusion research second only to that given the Soviet space program.

Drummond estimates that five and perhaps 10 times as many scientists and engineers are working on the Russian program as on the American. The incentives of pay and housing considerations offered Soviet scientists to enter plasma and fusion research are good even by Western standards, Drummond said during a recent demonstration tour of fusion research laboratories in GA's John Jay Hopkins Laboratory outside San Diego.

- **Milestones**—The years have produced three solid accomplishments that rank as "major" in fusion research:

(1) Physicists at Lawrence Radiation Laboratory at Livermore have produced the only "really incontestable evidence of controlled fusion," say the GA scientists. For a thousandth of a second, the Livermore team held deuterium plasma at 30 million °K, long enough to count a few thermonuclear neutrons that indicated fusion was taking place in the "heavy hydrogen."

(2) Russian physicist Mikail Joffe has demonstrated that plasma instabilities can be overcome. These "flute instabilities" drain energy from the plasma by collision or leakage of the plasma stream to the sides of the experimental equipment when the stream escapes the containment of magnetic fields. By arrangement of four electrical conducting rods ("Joffe Bars") the Russians have held plasmas of 50 million degrees for a tenth of a second, and the GA scientists said no reason was known why the arrangement could not have worked for at least 10-30 seconds.

(For reasons inscrutable even to Russians, Joffe has been removed from further developmental work on his plasma-containment system. "This was the best news we'd heard in years," Drummond commented.)

(3) Development by the General Atomic team of theoretical and experimental physicists of the "shot-gun approach" to the fusion problem. The approach, being adopted by Federal research laboratories here and abroad, offers two advantages, says Dr. F. Robert Scott, one of the dozen experimental physicists working on hydrogen fusion.

- **Shot-gun offense**—The first advantage, Scott said, lies in the chances of achieving the temperatures of 100-400 million °K needed to "ignite" or fuse the atoms of deuterium or heavy hydrogen. With the shot-gun method, intense heat apparently can be achieved by slamming a stream of plasma (500,000 mph is Scott's present working a celeration) against a magnetic wall; th converts the kinetic energy of the mo ing plasma stream into random he energy on impact. The GA teams no work at 4 billion °K.

The other advantage to "shot-gu ning" the plasma lies in breaking th entire problem of fusion research in problem "segments" which can be a tacked in detail by the theorists an the experimentalists together.

The method already has produced new type of magnetic container calle the "toroidal multipole machine," und development by Dr. Tihiro Ohkaw head of experimental physics at GA Four electrical conductors "shape" magnetic field around a toroidal vacuu chamber, squeezing the plasma togeth in the center. An advantage of the toro dal multipole that is attracting oth laboratories to explore its effectivene is that plasma which escapes from th center of the torus is piped back arou the field lines and into the main plasm stream again.

- **The equalizer**—While the Ru sians may be ahead of the U.S. in theo retical physics, Scott is not convince they have any great lead in the exper mental field. There may be no lead.

Scott emphasizes that none of th laboratories come anywhere near achie ing the theoretical minimums of plasm pressure, temperature, and particle de sity required for a fusion "chain rea tion." Because the pressures of the u controlled fusion occurring in the Su and the H-Bomb cannot be reproduce in the laboratory (400 billion Earth a mospheres), temperatures of at lea 200 million to 400 million degrees mu be used to compensate for the Sun greater pressure and smaller surfa losses.

Dr. Park Miller, Jr., head of fusion research at GA, says the mi mum plasma density required is 1 x 1 particles per cubic centimeter held for least one second. None of the expe mental machines achieve density tim approaching these requirements, the G scientists agree.

New Delta facility . . .

TIROS Launches To Be Moved to WTR

TIROS I's 'dog-leg' course from East Coast considered a hazard; completion of new launch site expected within 18 months

by Hal Taylor

THE SPACE AGENCY has disosed plans to build a *Delta* launch caability on the Western Test Range.

The facility will enable NASA to void the predicament it faced last eek attempting to launch the *TIROS I* tellite into polar orbit using a dogg maneuver that placed the spacecraft various times during the dangerous unch phase over the land masses of uba and Panama. Such a maneuver is quired by Cape Kennedy's East Coast cation.

Construction of the West Coast unch pad, which permits direct launch to polar orbit, will be completed in bout 18 months. It will be funded in e space agency's Fiscal '66 budget.

The *TIROS* launch—the first of the rtwheel configuration series—was heduled for Jan. 21. If it is successful, will be the first step leading to a joint ASA and U.S. Weather Bureau *TIROS perational Satellite (TOS)* system. The *OS* program calls for six launches and scheduled to begin in late 1965.

The critical dog-leg maneuver in the *IROS I* launch was slated to begin at 0 seconds after launch during the first age burn. Initiated by an autopilot, a w right maneuver takes place between lorida and the Bahamas. Six seconds ter second stage ignition, the dog-leg completed by a 74-degree right turn. his puts the satellite over Cuba at an titude of 100 miles and later over anama. The final push into polar orbit accomplished by firing the third stage the *Delta*.

Plans called for the first stage to op into the Caribbean about 1,100 iles from Cape Kennedy. The second age was expected to drop into the outh Pacific.

The flight plan called for *TIROS I* orbit the Earth at a near-circular 0-mile altitude. If successful, the sat*lite* was to be renamed *TIROS IX*.

• **Design details**—*TIROS I* resemes its eight predecessors only in its hat ox structure. The 18-sided satellite, hich weighs 305 lbs., stands 22 in. gh and has a diameter of 42 in.

Among the new components to be tested for the first time are digital clocks, control system, horizon scanners, solid-state commutators for telemetry and a new triggering system for the cameras.

If the launch was successful, *TIROS I* was to be injected into orbit over the Pacific Ocean about 300 mi. west of Quito, Ecuador, at a point 84° west longitude and 0° latitude.

Complete coverage of the Earth's cloud cover is possible because of a combination of the satellite's cartwheel configuration and its peculiar polar/Sun synchronous orbit.

In a Sun-synchronous orbit, the westward drift of the satellite is about one degree daily, the same rate and direction at which the Earth moves around the Sun. As a result, the Sun is always behind *TIROS*, putting the satellite in a favorable picture-taking position all year long.

In addition, the satellite will roll along its near-polar orbit at about 10 rpm, much like a cartwheel. This will permit cameras in its sides to view the Earth once during each revolution, and thus photograph the entire Sunlit portion of the Earth daily.

• **Flight description**—Thirty-six hours after launch, the two half-inch vidicon cameras are turned on. They have a capability of taking 400 pictures daily.

The satellite's 10-rpm roll is directed by two dynamic control (DYCON) units. The units also control camera timing and magnetic attitude coil currents that steer *TIROS* to the cartwheel attitude and maintain it in that position.

Soon after burnout of the *Delta's* second stage, the satellite is spinning at a rate of 125 rpm.

To reduce this to the desired rate, a timer triggers two weights attached to cables wrapped around the outside of the satellite. As the weights uncoil, they reduce the spin to 10 rpm and then automatically drop off the spacecraft.

The television camera systems are similar to those carried on the previous eight *TIROS* satellite missions. They have a resolution of about two miles at picture center.

The cameras, mounted on the side of the spacecraft, are canted 26 degrees to each side of the plane of the satellite's rotation so they can view the Earth once every revolution (every six seconds). ■

Thiokol Reported Winner of Two 156-in. Contracts

INDICATIONS ARE that Thiokol Chemical Corp. will handle two of the three new contracts in the large solid rocket program funded by the Air Force.

Unconfirmed reports as M/R went to press had Thiokol winning Packages 13 and 15. Lockheed Propulsion Co. won Package 14 and the last system—Package 16—has not yet been awarded.

Package 13 consists of the re-use of the 156-in. motor case scheduled for its first firing at Thiokol's Brunswick, Ga., facility next month. The monolithic case will be re-loaded and fired with a new nozzle and this contract includes thrust vector control experiments.

Package 15 consists of an upper-stage 156-in.-dia. reinforced plastic elliptical motor generating around 400,000 lbs. thrust. The Thiokol approach in the proposal included a submerged nozzle to meet the mass fraction specifications.

The Lockheed program involves reloading and firing a 156-in. segmented motor case built and fired last year by Thiokol in the original 156-in. program. The thrust level i about 1 million lbs. and the Lockheed package includes both nozzle and TVC developments.

LTV leadership through versatility Whatever the challenge . . . whether it's manned aircraft, versatile space vehicles, advanced weapon systems, super powered communications or military electronics, engineers and scientists at Ling-Temco-Vought are encouraged to probe beyond the limits of present technological knowledge, to anticipate and solve the innumerable problems related to the space age.

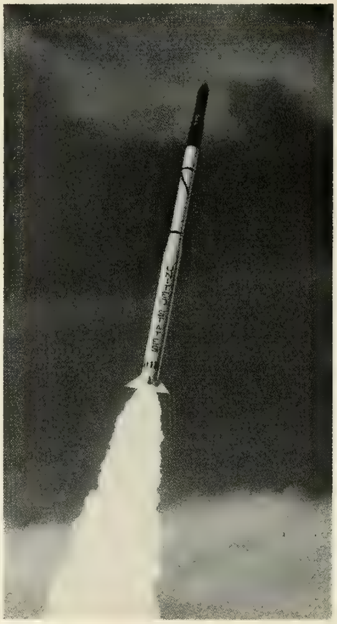
LTV's technical team has found this approach to engineering involvement provides opportunity for engineering versatility and professional satisfaction. We believe you will, too.

LTV's enviable position in the aerospace industry is strengthened by LTV Astronautics Division. Today, this division is providing leadership in the "state-of-the-art" for space systems synthesis, development, manufacture and operations on scores of space programs. Among the division's numerous aerospace activities are the development of MMU, a Modular Maneuvering Unit; NASA's versatile SCOUT launch vehicle; ERMU, an Experimental Remote Maneuvering Unit, plus extensive company-sponsored research and customer-funded studies.

Engineers and scientists can discover a creative and stimulating environment at LTV and living at its best in Dallas, a modern city offering temperate climate, abundant housing, and economical living costs.

LTV

ASTRONAUTICS DIVISION



A vigorous participant in the LTV complex is LTV Vought Aeronautics Division. From its 90-mile-an-hour biplanes of yesterday, LTV Vought Aeronautics has progressed to high performance aircraft including F-8E CRUSADER; the Navy's light attack A-7A with close troop support capabilities and the tri-service XC-142A V/STOL. Designed for versatility, the XC-142A is a tilt-wing craft incorporating the vertical take-off advantages of a helicopter with the speed of a transport. Engineering effort at LTV on advanced missile systems has developed additional technology for several new generation weapons.

Professional personnel can share in our growth and be part of a vital team in which initiative is encouraged and rewarded by investigating our current assignments.

LTV

VOUGHT AERONAUTICS DIVISION

LING-TEMCO-VOUGHT HAS EXCELLENT ENGINEERING POSITIONS IN ALL DIVISIONS. PRESENT REQUIREMENTS INCLUDE:

PROPULSION ▪ AERODYNAMICS ▪ STRUCTURES DYNAMICS ▪ STRESS ANALYSIS ▪ ELECTRO-OPTICS ▪ SPACE COMMUNICATIONS

TRAJECTORIES ANALYSIS ▪ CONCEPTUAL DESIGN ▪ THERMO MECHANICS

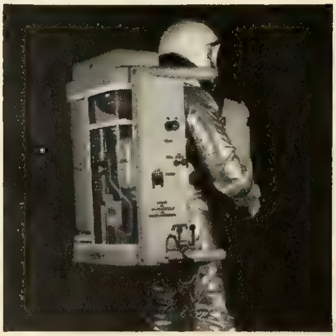
plus many others

LTV

LING-TEMCO-VOUGHT, INC.

P. O. Box 5907 Dallas 22, Texas
an equal opportunity employer

OTHER LTV DIVISIONS: LTV ALTEC • LTV CONTINENTAL ELECTRONICS • LTV LING ELECTRONICS • LTV MICHIGAN • LTV MILITARY ELECTRONICS • LTV RANGE SYSTEMS • LTV RESEARCH CENTER • LTV TEMCO AEROSYSTEMS • LTV UNIVERSITY • KENTRON HAWAII, LTD.



Circle No. 4 on Subscriber Service Card

echnical Countdown

MATERIALS

oron Fiber Composite in Labs

The Air Force has produced laboratory samples of a oron/plastic composite potentially as strong as high strength teels, structurally rigid and as light as magnesium. The comosite may have temperature abilities greater than aluminum nd magnesium and it should be easy to fabricate. Its orrosion resistance is said to be high. The material would ake possible large weight savings in aircraft and space ehicles without sacrificing either strength or stiffness.

ew Tungsten Welding at Martin-Orlando

A refinement of the Martin-developed vapor phase hermochemical joining process yields joints in pure tungsten uch stronger than any produced by other methods, say esearchers at Martin Co.'s Orlando Div. Samples of 0.020 . cross-section have shown yield strengths of 107,000 psi at 00°F. All test failures occurred in the parent metal and ot in the joint. The weld is made by the thermochemical eduction of tungsten hexafluoride with hydrogen at elevated emperatures. Deposition rates approximate those of electroorming and the temperatures are below that of recrystallizaion—thus not affecting the metallurigal and mechanical roperties of the parent metal. Martin workers feel the rocess is applicable to other refractory metals.

omputerized X-ray Film Reader Perfected

An automatic, computer-based method of reading x-ray ilms to detect welding flaws will cut examination times by 0% while increasing the process reliability. Developed by ockheed Missiles & Space Co., the flexible computer deection method allows flaw criteria to be programmed into he machine for any desired flaw size or proximity to other laws. The system scans the film with a vidicon tube proucing a video signal, which is fed into the Video and Digital rocessor Unit. The image is examined line by line for flaws nd each is divided into 230 points. These are fed into the eneral purpose computer. The flaw pattern is transferred to memory mosaic and a routine then analyzes the pattern nd produces a list of the geometric configurations of the laws. The end result is a typed list covering the flaw size, osition and proximity. With literally hundreds of thousands f feet of such film examined monthly as a matter of course n current programs, the Lockheed system is tapping a subtantial market area.

etal Cracking Prediction Research Under Way

A three-year project at Lehigh University is aimed at ncreasing the understanding and improving the means for redicting metal failures caused by cracks in thin metal plates nd shells. Sponsored by NASA's Office of Advanced Reearch and Technology, the study should develop empirical aws to predict the total life of structures prior to failure aused by cracks. A series of thin metal plates—flat and ylindrical—will be subjected to bending, twisting and inernal pressure. Long term corrosive testing is planned to heck this effect on crack growth.

SPACE MEDICINE

Physiological Effects of Magnetism Studied

Continuing studies of magnetic field effects on the uman body are being performed at the Naval School of Aviation Medicine, Pensacola, Fla. Under D. E. Beischer, six men were exposed to a field of 50 gamma (1 gamma equal to 10^{-5} oersted) for a period of 10 days. Except for some observations on the flicker-fusion threshold, no physiological or psychological effects of very low magnetic fields resulted, although continued research is needed, Beischer said. Magnetic field at the lunar surface was represented as 1/1000 that of the Earth.

Deep Space Physiological Sensors Sought

NASA is looking for development of non-implanted and non-attached physiological sensors for deep space use. RFPs have been issued to a number of contractors for a 12-month study of ways to monitor more than one variable on one signal. Detector and associated electronics must have a response time of 10 milliseconds. Bids were due at the Electronics Research Center Jan. 21.

ELECTRONICS

Programming an Air Force Computer Problem

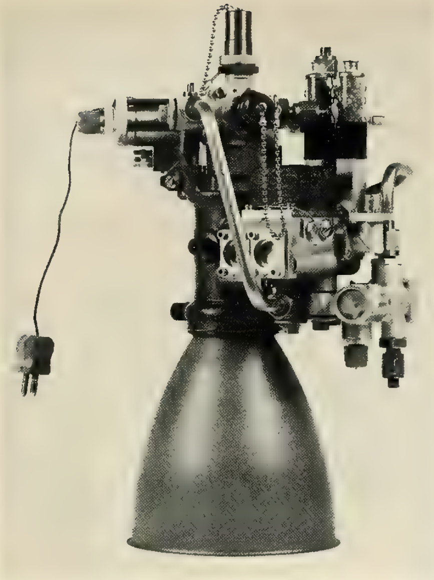
With almost 500 computers in use in the Air Force, Gen. Bernard A. Schriever, AFSC Commander, says the most serious problem is in programming and in the growing number of programmers needed. Schriever told the Houston Junior Chamber of Commerce that the time and expense of programming may eventually outweigh the advantages of the computers themselves. The most promising solution seems to be pre-programmed or implicitly programmed computers, which would allow the user to communicate directly with the computer. Air Force Forecast studies have identified several technical advances that should make implicit programming feasible.

Scanning Laser May Lead to RAC Memory

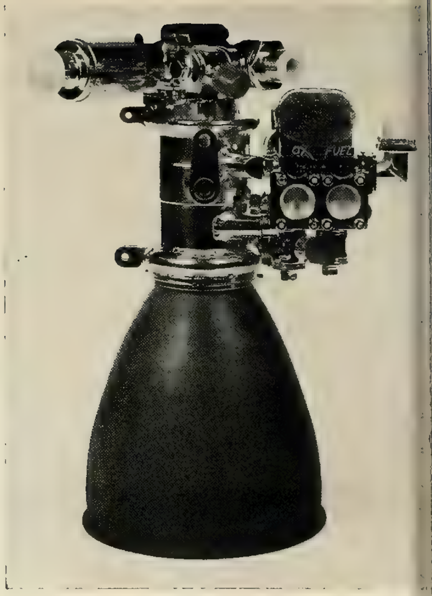
Use of a scanning laser beam with a photochromic array could lead to a random access computer memory that "looks like it may be a real important step forward" according to Dr. Richard J. Burke, President of H Nu Systems Inc., Palo Alto, Calif. At least two organizations have developed prototypes to demonstrate the technique. Packing density would be governed by laser spot size, which could be adjusted to 0.001-in. diameter, or smaller if warranted. The Electronics Div. of National Cash Register Co. quotes resolutions of 1,000 lines per millimeter or more as feasible for photochromic dispersions. Photochromic materials under investigation for computer memory applications change optical density under ultravio'et light. No development process is required and the information can be erased by heat. Photochromic work at NCR has been under way for a number of years, with the aim of developing new printing and data storage concepts. However, a company spokesman said that random access photochromic storage devices were not being developed.

Navy Technical Research Ships Outfitted

Two U.S. Navy technical research ships—USS Belmont and USS Liberty—are completely outfitted for upcoming programs involving ship-shore-ship experiments using the Moon as a reflector for signal propagation and reception. The former WWII Victory Ships were converted under a $10-million contract by Willamette Marine Div. of Willamette Iron & Steel Co. Electronic systems were supplied by F&M Systems Co., Dallas, a div. of Fischbach and Moore.



LEFT: The original Surveyor thrust chamber assembly, Model TD-280. RIGHT: Current design, TD-339. The major changes in the two models are in packaging and the fuel.



space propulsion

Surveyor Engine in Final Development

by John F. Judge

DENVILLE, N.J.—The *Surveyor* vernier thrust chamber assembly is in the final development stage at Thiokol Chemical Corp.'s Reaction Motors Div. under contract to the Jet Propulsion laboratory for NASA.

Three of these engines will provide propulsive power to the spacecraft for mid-course guidance, attitude control before and during main retro rocket descent to the lunar surface, and prime retro power after the main retro unit has been jettisoned.

The engines will shut down a few feet above the lunar surface, allowing the spacecraft to drop unharmed—ready to gather and transmit data essential to the *Apollo* program.

The engines as they exist do not interfere with any *Surveyor* experiments. This requirement is part of the contract with RMD and engine qualification includes an ability to survive the lunar environment without leaking remaining propellant or contaminating the immediate vicinity in any way.

The present vernier engine design (Model TD-339) is actually an improved version of RMD's earlier efforts (Model TD-280) in the *Surveyor* vernier area.

• **Component breakdown**—The TD-339 has three major assemblies—the thrust chamber and injector components, the dual propellant throttle valve, and the dual propellant shutoff valve. The engine is throttleable over a minimum range of 3.5 to 1.

The vacuum thrust is 30 to 104 lbs. with respective chamber pressures of 70 and 250 psia. The thrust chamber is regeneratively cooled and based on the RMD Voramic design—vortex injection with concentric shell-type 347 stainless construction and a cooled silicon carbide ceramic throat insert.

A radiation-cooled molybdenum-0.5% titanium nozzle extension provides an area ratio of 86 to 1 and the entire engine has a vacuum specific impulse of about 287 seconds.

The dual propellant throttle valve provides thrust variation by controlling the flow of propellants to the thrust chamber. The mixture ratio (O/F=1.5:1) is also handled by the proprietary component.

In principle, the throttling valve operates by maintaining a constant pressure drop across a flow area, which is varied as a function of input current using a torque motor to convert electrical signals to mechanical motion.

The propellant shutoff valve is an on-off device controlling the flow of both propellants to the thrust chamber. The poppets are linked to provide fo simultaneous entrance of propellants The actuating gas is helium, controlle by a solenoid pilot valve in the assembly

The chamber temperature is abou 4,700°R and the total weight of the en gine dry is 5.99 lbs.—chamber and in jector, 2.98 lbs.; propellant lines an valves 3.01 lbs.

• **Major changes**—The current con tract—directly with JPL—gives RM the responsibility for the thrust cham ber assembly. Associated tankage, bot propellant and pressurizer, is being de livered by Hughes Aircraft Co., build ers of the *Surveyor* spacecraft.

The major change in the TD-339 a compared to the TD-280 model derive from the substitution of a monomethyl hydrazine hydrate for the original nea monomethylhydrazine. This fuel com position has a lower decomposition rat and can withstand higher temperature than the pure fuel. The oxidizer i N_2O_4-NO (90-10 by weight).

In regeneratively cooled engines, th control problem is complicated if th coolant fluid does not remain liqui throughout the system. Throttling an restart functions tend to become "soft' since the coolant is not in a complet liquid phase but involves vapor/liqui transients.

This liquid/gas problem in the system existed with the earlier *Surveyor* vernier engine model and, while the unit met specifications with mechanical improvements, its performance margin was limited.

The MMH-H_2O substitution changed this and eliminated the necessity for the mechanical improvements in the TD-280. The entire problem is characteristic of such small engines—high temperatures associated with low coolant flow.

The *Surveyor* TD-339 engine has been through 39 full-scale tests in an initial 60-day program. These tests have been run at the specification temperature extremes under both simulated altitude and sea level conditions. Testing is continuing at this time on the main development program to demonstrate the exact margins of this design.

To date, a total of 680 firings, for an accumulated test time of 36,000 seconds, have been accrued on the *Surveyor* program without a single catastrophic engine failure.

- **System functions**—In operation, the propellant tanks are pressurized by firing a squib-actuated helium release valve. Propellant head is maintained to the engine shutoff valve before launch and throughout the mission.

Electrical signals from the *Surveyor* flight control system open the propellant shutoff valve, and ignition in the combustion chamber is hypergolic. Throttle valve settings corresponding to any desired thrust level are accomplished by electrical signals from the flight control system. Continuous signals to the throttle valve will vary thrust in each chamber. Spacecraft signals actuate the one gimballed engine as necessary for roll control.

Removal of the electrical power will close the shutoff valve and shut down the engine—but the propulsion system will remain pressurized and in a ready state, capable of instant restart.

All vernier engines and the propellant system will be kept in the 0-100°F thermal range. Most of each engine's surface is gold plated, with a black-body paint covering those surfaces facing the sun. Thermal balance will be maintained during shut down by the combined absorbitivity and emissivity characteristics of the coated surfaces.

- **Engine family**—The Voramic concept in small engine design is an old idea at RMD. The name is derived from the combination of vortex injection with a cooled ceramic throat insert.

Recent work in the area has led to several improvements in the thermal control of such engines. The innovations incorporated by RMD into what it calls its Radiamic engine also increase the throttling and pulsing potential of the basic Voramic design by maintaining an all-liquid system, i.e., no vapor/liquid transients.

The cooling approach in the Voramic chamber includes liquid coolant around both the combustion chamber and the nozzle assembly. This permits a straight-through cooling jacket design, which in turn cuts down the coolant liquid velocity. Such small engines characteristically have high temperatures associated with low coolant flows.

The ceramic throat insert has multi-directional heat dissipation ability, which tends to keep down the heat transfer to the coolant liquid.

The improvements were directed at two characteristic problem areas—heat transfer to the coolant liquid had to be lowered and heat stored in the insert had to be handled after engine shut-down to insure clean restarts. Such engines can be designed for pulse operation and this increases the heat soak and temperature protection problems.

The improvements can best be illustrated using the TD-339 *Surveyor* vernier engine configuration. The first step is to optimize the injector system—going to a new vortex design that achieves maximum cooling effect by swirling the fuel through the combustion chamber. The oxidizer is injected radially.

This improvement has been tested in actual full-scale firings in which the injection scheme reaches a cooling effect of about 25% in heat transfer reduction. The engine still runs at between 95 and 98% C* with this method.

The second improvement involves proprietary changes in wall construction of the conventional Voramic chamber. This concept, the heart of RMD's Radiamic chamber, includes extensive modifications to the fuel cooling jacket, plus the incorporation of other elements fashioned from the newer high temperature refractory alloys.

Another improvement lies in choosing certain advanced materials for the throat insert—materials with low heat transfer abilities, and more important, a low heat capacity, which lowers the stored heat problem after shutdown.

The latter general improvement increases propellant mass volume in the cooling jacket to minimize heat soakback.

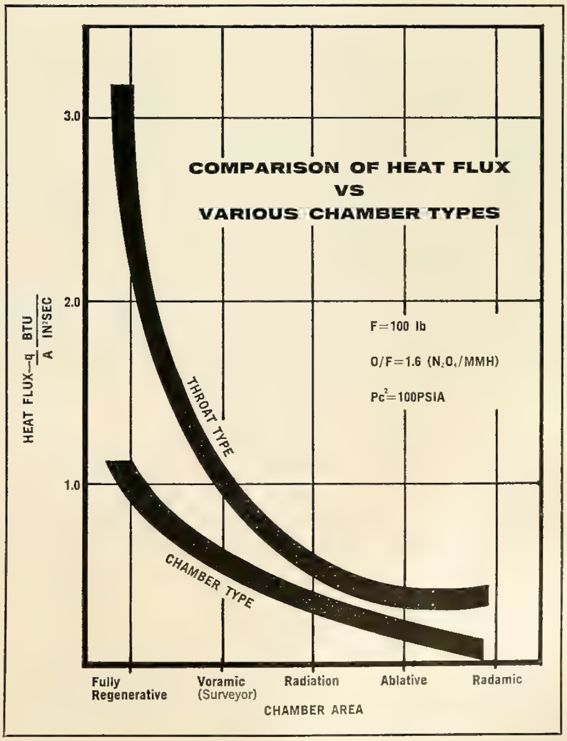
- **Synergestic heat blockage**—RMD researchers emphasize the Radiamic engine's extremely low heat rejection rate (Q_r)—2.5 to 3.1 Btu per sec. This is lower by a factor of four over comparable engines in the same thrust class that normally have a heat rejection rate of approximately 12 Btu per sec. The optimized injection scheme accounts for nearly 50% of this reduction, Radiamic wall construction and nozzle improvements accounting for the rest.

The total effect is to increase combustion efficiency with Earth-storable propellants. The Radiamic engine is extremely rugged and extremely safe. There have been no catastrophic failures in tests—even when a test has been rigged for one.

The system is insensitive to operational variations. A complete nozzle could be lost and some propulsive energy would remain. There would be no damage to the surrounding structure. This is especially important in manned applications and where the propulsion unit is buried in the vehicle structure.

The concept has been demonstrated in 100-lb.-thrust-range rockets and RMD experts feel the design is easily adaptable up to 10,000 lbs. thrust. ■

HEAT FLUXES vs. various RMD chamber designs.



Army Moves To Simplify Servicing

RCA division expected to receive contract for multi-system test equipment slated for use with Shillelagh, Lance and TOW

by Michael Getler

BURLINGTON, MASS.—The Army's long and circuitous battle to get a single test and repair system into the field able to service several tactical missile systems is finally moving toward fruition.

The Army Missile Command (AMC) at Redstone Arsenal, Huntsville, Ala., is expected to award a contract within the next few weeks to Radio Corp. of America's Aerospace Systems Div. here for development and fabrication of a design model of a multi-application test and repair system aimed at support of *Shillelagh, Lance,* and *TOW* missile systems.

The service, according to Army project officers, is expected to move beyond the design model and engineering model development and into production with this equipment to be able to field it as Army divisions are being supplied with the first operational missiles.

The equipment to be fielded is known as ETS-3 (Electronic Test Set). It is an outgrowth of the Army's long effort to develop the very broad capability Multi-system Test Equipment (MTE) program, (M/R, May 20, 1963, p. 38) and actually reflects the recent reorientation of the MTE program to meet two support objectives:

—the divisional support in the 1965-70 time period of the relatively simple *Shillelagh, Lance,* and *TOW* systems;

—the divisional and corps support of these three systems, in addition to the more complex air-defense missile and radar-associated systems such as *Mauler* and *AADS-70,* which may come along in the post-1970 period.

● **System described**—The ETS-3 equipment will meet the first part of this dual support requirement. This equipment consists basically of a single van-mounted, helicopter-transportable electronic test set capable of supporting the three pre-1970 missile systems. The system also can include a second "helihut" that serves as a repair team shelter and work area. Gross weight is 7,500 lbs.

Of the three missiles and "system-peculiar equipment" that ETS-3 will service, the *Shillelagh,* which is mounted on the Sheridan assault vehicle, will be deployed first, probably early next year, and will involve a period of contractor field support prior to ETS-3 use. The *TOW* and *Lance* will reportedly follow *Shillelagh* deployment. The ETS-3, according to the Army, "will be ready for deployment in 1967."

Engineers report that of the three missiles, *Shillelagh* is the most complex from the test standpoint, that *Shillelagh* and *TOW* have the most common requirements, and that *Lance* is the most unique.

● **Program history**—The MTE program got its start about eight years ago in projects such as RCA's DEE and Nortronics' DATICO, and has been brought along by the Army through the years at a total cost now estimated at about $20 million.

This much broader MTE program, which is aimed at eventually supporting all future Army missile systems, consists of a system that is contained primarily within three basic vans; two electronic test sets (ETS-1 and ETS-2) and one hydraulic test set (HTS-1). The equipment developed by RCA under the MTE program has also been brought to the design model stage for each test set and is now undergoing acceptance checks by AMC.

Because of the revised outlook for *Mauler,* however, now described as in a "feasibility demonstration program," and the still-uncertain future of *AADS-70,* this equipment is not likely to be developed any further, pending stronger commitments to missile production, and is now "in limbo," as one Army officer puts it.

● **Frequencies used**—The two MTE electronic test sets (ETS-1 and -2) in effect divide the frequency spectrum associated with Army missile systems. One set operates in the DC to low-frequency range, and the other the VHF and including up to X- and L-band in the microwave region, with capability, according to RCA, to go to S-band. These higher frequencies are those that would normally be associated with sophisticated air defense missile radar.

The ETS-1 portion of MTE also includes an RCA 3110 digital computer which is linked by means of a hard-wire connection with the other major MTE elements to allow fully automated test and checkout of the missiles. Included in the ETS-2 van is the test control console, which handles switching sequence, magnetic tape control and storage, data conversion, input/output devices, and print-out.

The ETS-3 equipment, in effect, takes the low-frequency capabilities of the ETS-1 van and the control system of the ETS-2 and combines them to come up with a field system able to support the first three, relatively simple, low-frequency systems that are to be deployed.

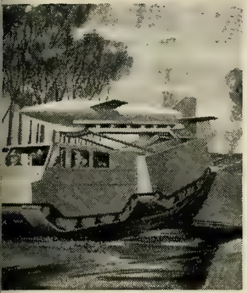
The ETS-3 will not have any associated hydraulics test systems as in the larger MTE concept, since the missiles to be serviced all have a very low density of hydraulics associated with them, according to the Army.

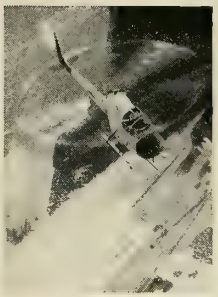
There is also no computer requirement for the ETS-3, again because missile system complexity reportedly does not demand one. The control device is a punch-tape sequencer. The test program is run from pre-programmed magnetic tapes, hermetically healed in cartridges for field use.

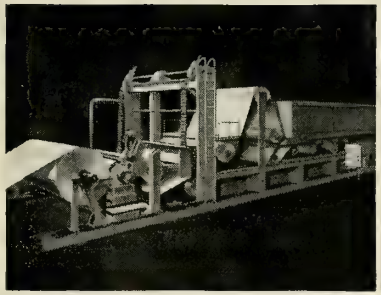
● **Advances triggered**—In developing ETS-3, engineers say important gains have been made, some of which grow out of the acceptance checks being performed on the MTE design models.

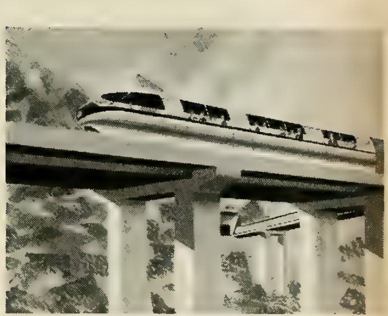
For example, the ETS-3 will make extensive use of silicon integrated circuits in all digital circuitry with an attendant size reduction from the solid-state miniaturized modules used in the MTE of about 4 to 1 in the control area. Use of the integrated circuits has also reportedly increased reliability about 7 to 10 times, and increased circuit speeds about 100-fold into the 100-mc region. Engineers point out that these changes could, in turn, be plugged back into the large-scale MTE equipment if a production go-ahead is ever forthcoming. ■

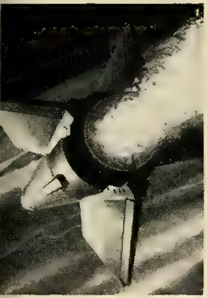
What single complex converts energy in so many ways?...

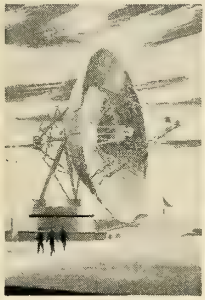

Engine starters and power generators for tanks and ground support equipment.

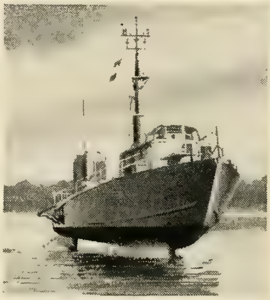

Starter generators for gas turbines, and auxiliary power units.

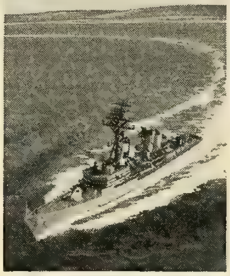

Industrial process drives for precise control of machine operation without gearing over a very wide speed range.

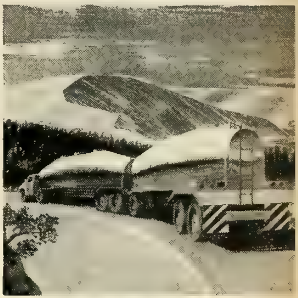

Drives for rapid transit and heavy road vehicles with stepless control of acceleration and deceleration.

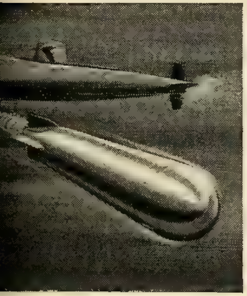

Servo actuators to operate directional controls of space vehicles, missiles, aircraft and torpedoes.

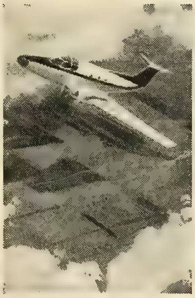

Antenna drives for air, ground or ship-borne installations.

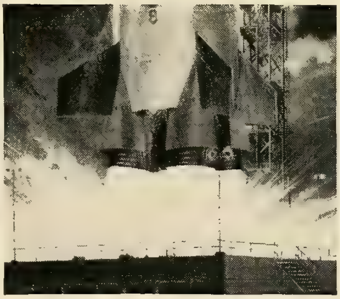

Variable-speed constant-frequency conversion units for hydrofoils.

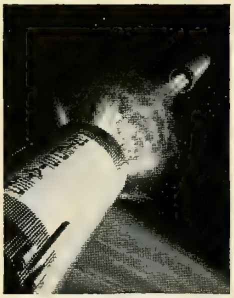

Static frequency changers convert electrical power from one frequency to another for ships and submarines.

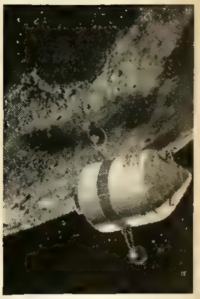

Electrical retarders provide a separate braking system for very heavy vehicles on long downgrades.


Brushless DC motors for torpedo propulsion and space environmental control.


Generating systems for commercial and executive aircraft.


Pumps and couplings to handle all types of liquids and gases for aerospace fluid systems.


Generating systems to operate at high speeds in high temperatures and in extreme environments.


Integrated cooling/hydraulic packages for electronic equipment in aerospace vehicles.

We do... but what we have shown reflects only our present capabilities. Our real orientation is towards the future . . . we are helping to create new concepts of power generation and conversion to help fellow man operate more efficiently on earth as well as in space. That's why they call us . . .

LEAR SIEGLER, INC.

POWER EQUIPMENT DIVISION
P. O. Box 6719, Cleveland, Ohio 44101
Phone: 216-662-1000

Fuel and fluid handling systems are designed by our Romec Facility in Elyria, Ohio

Circle No. 5 on Subscriber Service Card

B2256-LS-A

MSC Control Center Seen Ready

Performance during aborted December GT-2 attempt verified installation's capability to assist in manned flight control

by Rex Pay

HOUSTON, TEX.—The Manned Spaceflight Control Center (MSCC) served as backup for the simulation and count-down of the *Gemini/Titan-2* (*GT-2*) test launch from Cape Kennedy Jan. 19, just as it did on the previous *GT-2* attempt aborted at the Cape on Dec. 9.

Operating on telemetry and tracking data—and performing ahead of schedule—during the Dec. 9 exercise, the MSCC demonstrated for the first time that high-density real-time data could be stored within its computers and made available upon random request to a large number of different users.

Ability to use these data effectively for flight control was well confirmed by this experience, says the prime contractor, Philco Houston Operations.

Telemetry data from the spacecraft were transmitted from the Cape launch pad through the *Gemini* Launch Data System and over telephone lines to Houston. There the data were routed through PGM telemetry ground stations and the main real-time computer complex at the MSCC.

Countdown status was also transmitted and processed for display in the MSCC.

● **Dry run**—In simulations prior to the first attempt to launch *GT-2*, use of tracking data from the previous *Gemini* tests showed that the X-Y plotboards could provide information with sufficient accuracy for control of the downrange trajectory for MSCC.

A team of NASA flight controllers manned the primary consoles and conducted operations similar to those planned when MSCC is able to take over prime control. At launch, the group monitored tank pressures as the engines were started and the fuel lines became pressurized. Then, as the instrumentation on the launch vehicle sensed an incorrect hard-over command to the steering motor, an engine shutdown was automatically initiated. Houston operators saw tank pressurization fall, and for some time afterward monitored conditions in the spacecraft.

● **Flight role**—Main function of the Manned Spacecraft Control Center is to increase the likelihood of *Gemini* and *Apollo* manned mission success by providing both routine and emergency support to the astronauts. The Center will transmit digital and verbal information to the spacecraft and crew concerning flight test plans, maneuvers, aborts, entry, onboard systems and consumables, and operations.

The Center collects and analyzes operational telemetry from launch vehicle and spacecraft, controls the target vehicle for *Gemini* rendezvous missions, issues up-data and commands to onboard systems by means of the remote-site Digital Command System, and directs recovery operations.

Remote stations in the world-wide Ground Operational Support System are all currently linked to the MSCC over 60-100 wpm teletype lines. In addition there is a video link to Cape Kennedy and a 40.8-kilobit data transmission line for *Titan*, *Agena*, and *Gemini* pulse code modulation (PCM) telemetry. And there are high-speed Dataphone links (2,000 bits per sec.) to bring in data from the Eastern Test Range sites and from Houston.

Three Eastern Test Range sources—tracking radars at the Cape and at Bermuda, and the GE/Burroughs impact prediction system—are linked to MSCC over duplicate parallel lines, making six Dataphone links in all for launch-phase data.

● **The plant**—The MSCC occupies a three-story building at the Clear Lake site of the NASA Manned Spacecraft Center in Houston. The lower floor of the building contains computer, communications, and switching systems to serve Mission Operational Control Rooms (MOCR's) on the second and third floors.

Each MOCR is capable of independent operation and each is served by two IBM 7094's in the Real Time Computer Complex and a Univac 490 Communications Processor. Of the two IBM machines serving each MOCR, one is on standby.

"The key factor in designing the MSCC was not to redefine the functions and requirements of the flight controllers used in Project *Mercury*, but to capitalize on their experience," said Dr. Walter B. LaBerge, head of the Houston Operation of Philco Corp.'s Western Development Laboratories. Philco WDL secured a prime contract of more than $30 million for building the MSCC.

LaBerge added that "we realized that a significant simulation capability was needed full-time to learn how best to control and support the missions."

The present systems enable simultaneous control of an operational mission and a simulation in the Center. Or, alternatively, two simulations can be carried out simultaneously. A simulation includes a spacecraft (either at Cape Kennedy or at the MSC), the MOCR and support areas, and simulated or actual remote site equipments—the whole operation being made as realistic as possible. Techniques for inserting faults into the simulation—such as outage of communications links to ground stations or the garbling of spacecraft telemetry—are being developed.

Constant utilization of MSCC systems is foreseen, and the control rooms are already expected to be booked well in advance. In particular, simulation exercises to develop techniques for controlling *Gemini* rendezvous will have high priority.

● **New problems**—Rendezvous is a much more difficult operation than was the *Mercury* flight. Many things are happening at the same time, and many more people will be involved. How people, equipment, and events are going to interact will be proven or worked out by simulation. "Right now," said LaBerge, "all flight controllers are anxious to get on the equipment to verify the operations they have been planning."

The rendezvous flights of *Gemini* have brought up new display problems. In *Mercury* flights the main summary display had a fixed trajectory. In *Gemini*, the variable launch azimuth and maneuverability of the spacecraft complicate mission displays.

In *Mercury*, the orbit was approximately circular. In *Gemini*, large excursions in altitude will occur in the planned elliptic orbits and incremental distances of 50 mi. will become important parameters. One aim of Philco's work at MSCC has been to provide sufficient capacity to plot rapidly and accurately any orbit required or any telemetry or trajectory information.

To provide a flexible display of information to the flight controllers, each is given a console on which he may request information from the computer by means of keyboards and numerical thumb wheels. Information is then displayed to him on 14-in. precision television monitors, in alphanumeric, graphical-analog, or scale and pointer form. He can demand hardcopy of any display by pressing a button. Most consoles have two TV monitors.

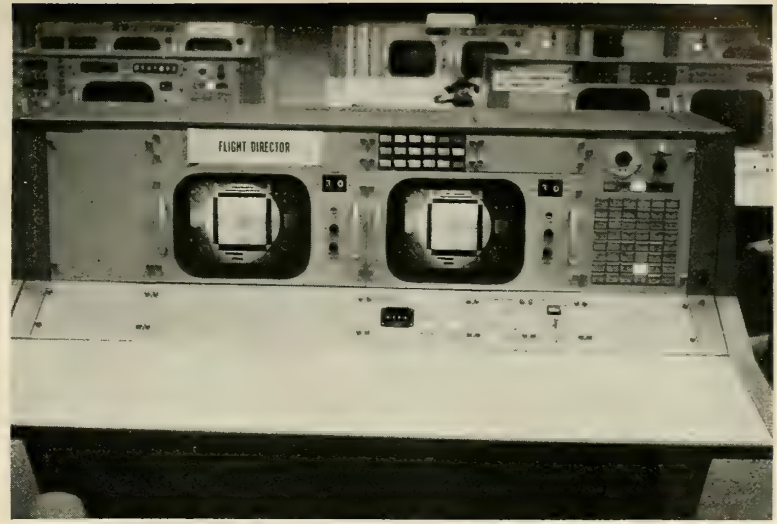
The flexibility built into the display system enables each console to meet the requirements of any specialist operator. Should a console fail, its operator can move to any other console and have immediate access to the information he wants to work with.

A vital piece of equipment in this respect is the main video switching matrix provided by Cohu Electronics. This handles 20-mc wideband video with no observable crosstalk in routing data from 64 digital-to-television converters to consoles throughout the MSCC.

• **The setup**—Typical personnel in the Mission Operations Control Room for *Gemini* rendezvous flights will include the Flight Director and his assistant, the Flight Dynamics Officers, Booster Systems Engineer, Life-Systems Officer, Network Controller, Operations Director, Spacecraft Communicator, *Gemini* Systems Engineers, *Agena* Systems Engineer, and the Retro-fire Officer. Each will have access to all incoming data but will, for the most part, select only that information relevant to his own task.

Each control room is also equipped with a set of group displays on one wall, which can be seen by personnel throughout the room. The largest in each set is a 10-by-20-ft. projection plot board with eight moving spots used to display mission status. Next to it, a smaller projection plotboard displays flight dynamics data and will typically be used to show the progress of launch and insertion. On either side of these are large projection television displays that can show selected data from the computer.

"That MOCR is going to be impressive beyond comparison," said one Philco spokesman. "The multi-color plotting display is going to be just very effective and the TV presentation of data is going to be very dramatic."



ONE OF flight controller's consoles in a mission operational control room at MSC.

All incoming and outgoing information, except voice messages, is planned to go through the Communications Processor and the Real Time Computer Complex. A 24-hour file of incoming data will be maintained on magnetic tape. Digital data from the RTCC is converted for television display by means of Charactron equipment supplied by General Dynamics/Electronics.

The 7094 updates the displayed data every half second and outputs data at the rate of 28,000 words per second. An indication of the amount of data being handled is given by the use of 500,000-word core memories (36 bits per word) in the Real Time Computer Complex.

Displays appearing on the console monitors are made up of Charactron alpha-numeric data superimposed on background slides. For the *GT-2* shot, about 60 different computer-directed TV presentations of data were defined by the Philco personnel supporting NASA. Instructions for programming by IBM of the computer for these data formats were completed, slides made for insertion into slide files, and programming instructions to call up these slides completed.

• **Massive data**—The Air Force SAGE system is more complex than the MSCC system in the sophisticated way it uses computers for data processing, but it does not handle nearly as much data.

The outstanding feature of the MSCC is not the functions carried out by the computers, but the mass of information they handle. "All the complex and exacting things are done by people," said LaBerge. "You cannot relegate this to a computer at this stage because of the developmental and unknown aspects of the missions. Therefore, simulation is the major way of bringing the flight controllers up to a state of readiness for this task."

Voice communications in the MSCC are handled by a system installed by North Electric, which provides up to 200 conferencing loops. The loops can include voice originating at the Cape, or at MSCC. The system design was difficult because many people will have to use a number of loops simultaneously and the requirements are likely to change from mission to mission. For example, Flight Director Chris Kraft may monitor five or more simultaneous conversations.

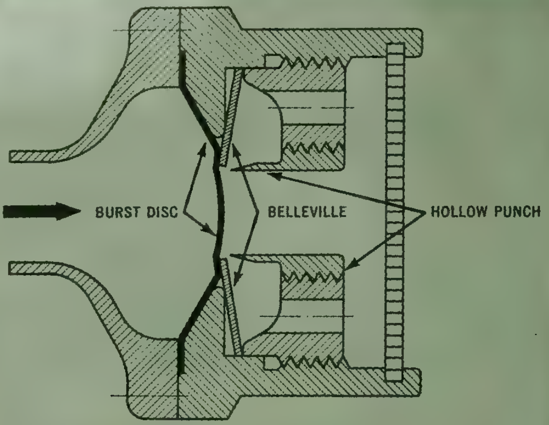
Incoming data to the MSCC arrives at irregular intervals and from a variety of world-wide sources. Telemetry data are received by the Wide Band Data Component and passed to PCM telemetry ground stations subcontracted by Philco WDL from Lockheed.

The Univac 490 communications processor takes these data into core memory, looks at their priority tags, decides in each case whether to interrupt RTCC operation or put the data into a queue, and dumps out the messages at the rate required by the RTCC. Some added formatting is done by a unit that frames the data into digital lines, establishing word blocks.

• **Other duties**—In addition to routing telemetry streams, the communications equipment carries out certain error checking routines and monitors the quality of communications links. These procedures are of particular significance in the task of routing outgoing spacecraft up-data and commands from the Master Digital Command System.

During an operational launch there is not enough operational capacity to allow a full simulation to go on at the same time, but this is the only occasion

Burst-disc assemblies allow system operation within 5% of burst pressure



Capable of being set to burst with an accuracy of 1%, Calmec burst-disc assemblies can be used in systems operating up to 95% of rupture ratings, and can withstand repeated cycling.

Each assembly is pre-tested for rupture setting prior to shipment without damaging the burst diaphragm.

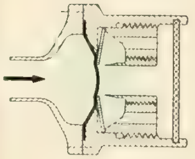
A burst disc assembly can be combined with a relief valve to guarantee zero system leakage up to the burst setting. After rupture, the relief valve can be used to conserve the system supply while maintaining overpressure protection.

Series 566 and 567 burst-disc assemblies are designed for use with most gases and special liquid applications; burst pressures to 3000 psi; operating temperatures from −65°F to +160°F. Units are available fully qualified for aerospace application.

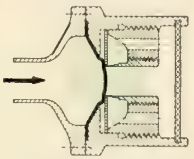
Custom designed assemblies can be made available with port sizes to 12 inches; pressures to 10,000 psi; and operating temperatures from −423°F. to +1000°F.

Write for 4-page brochure describing operation and specifications.

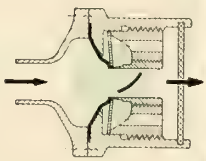
SEQUENCE OF OPERATIONS



Normal Position — Belleville spring provides partial backup of diaphragm; adjustment of spring permits accurate calibration of burst setting.



During Snap-Over — Burst diaphragm in contact with punch during snap-over of Belleville spring; pre-loading assures burst at desired pressure.



Full Diaphragm Shear — Belleville spring in snap-over position, complete rupture of burst disc center portion assures full flow area instantaneously.

CALMEC

CALMEC MANUFACTURING CORP.
5825 District Boulevard • Los Angeles 22, Calif. • (213) 588-6204 • TWX (213) 773-5796

Circle No. 6 on Subscriber Service Card

on which the simulation capacity is so limited. Actual limit of the system capacity is related to the total amount of telemetry being put into the communications system.

It is expected that one control room will work on an 8-hour shift for simulation, and the other will operate to meet mission requirements. Initially, round-the-clock mission operations will be sufficiently infrequent to program two or three shift operations for the second control room most of the time. Dual two-shift missions would call for a total staff of 209, including 28 management/administrative staff.

- **Growth plans**—Expanding the present capacity of the MSCC, if required, would be largely a matter of providing further communications, processing, and control facilities. Technically, it would be relatively straightforward—to increase the capacity of the systems. Some limitations would remain, however. Simultaneous launches and recoveries will remain difficult to accommodate.

An added 7094 (for a total of five) is planned for the MSCC. It will be operated by IBM and NASA to test mission programs. This could be put on line to expand system capacity.

There are enough things going on and enough data to evaluate during a mission so that each operator in the control room will require support from a staff group. To facilitate this, the data is not only routed to MOCR consoles but can also be routed to Staff Support Rooms.

They can also add to the data and direct the attention of the principal flight controllers to alterations and significant points. These staffs also analyze the quality of the data and advise the flight controllers as to what reliance to put on it and the best estimate of future behavior of the systems represented by the data.

Staff Support Rooms are located around each MOCR. Both floors have a Flight Dynamics SSR, Vehicle Systems SSR, Life Systems SSR, Flight Crew SSR, Network SSR and Operation and Procedures SSR. The second floor of MSCC also has facilities that simulate remote sites and provide eight dummy remote sites, a simulated message center, and a Master Digital Command System Room. These are absent on the third floor, which has in their place a Recovery Control Room and a large area housing the television display generators.

The IBM 7094's are used about one-third as a computer and about two-thirds as a switch. They check incoming telemetry against nominal limits and perform trajectory calculations. Otherwise, all functions that are not console-initiated are computer initiated. ■

Students Find New Throttling Method

NASA experts praise development by West German group, see possible use in advanced programs; design eases deep throttling, mass flow control

by William S. Beller

STUTTGART, WEST GERMANY—A novel concept for controlling a deep-throttling engine, marked "outstanding" by a highly placed NASA official, was recently developed in a handmade rocket test facility operated by a group of technical students.

"The work is of high interest and on the forefront of technology," James R. Flanagan, chief of liquid propulsion experimental systems at NASA headquarters, told MISSILES AND ROCKETS. Referring to a paper describing the concept by Lutz T. Kayser, chairman of the student group, Flanagan said "this concept of his, if developed under the proper auspices, could certainly be considered for some engine programs we have now or will have in the future."

Flanagan drew a parallel between Kayser's work and that being done by TRW Space Technology Laboratories on a 10,000-lb.-thrust lunar descent stage for LEM; thrust can be controlled over a 10:1 range. Kayser covers a similar or larger range. Nevertheless, both engines use a variable-area injector coupled to variable venturis to get their thrust control. The difference lies in the mechanical means. STL uses a conventional axial cavitating venturi; a tapered rod is moved in and out of the venturi to control the flow rate. A separate venturi is used for the fuel and the oxidizer, which are yoked together and coupled to an actuator.

Kayser, similarly, uses two cavitating venturis, but his are axial types controlled simply by the flexing of a diaphragm. Unlike the STL type, Kayser's venturis do not use seals in the design, and thereby eliminate a possible weak point. Similar advantages can be related for the variable injector head.

Flanagan's appraisal is that "Kayser's system might be better for large engines because it has a larger mixing area for the oxidizer and fuel." He pointed out that the STL design, based on a Jet Propulsion Laboratory concept, might present problems when the engine thrust goes much over 10,000 lbs.

Kayser claims that his control system can cover a 25:1 thrust range with or without mixture-ratio variation. For this purpose he developed a new type of injection system. The injection head is constructed with two flanges separated by a ring diaphragm, as shown in Fig. 1.

The fuel and oxidizer are injected on

FIG. 1—Controllable injection head for deep throttling.

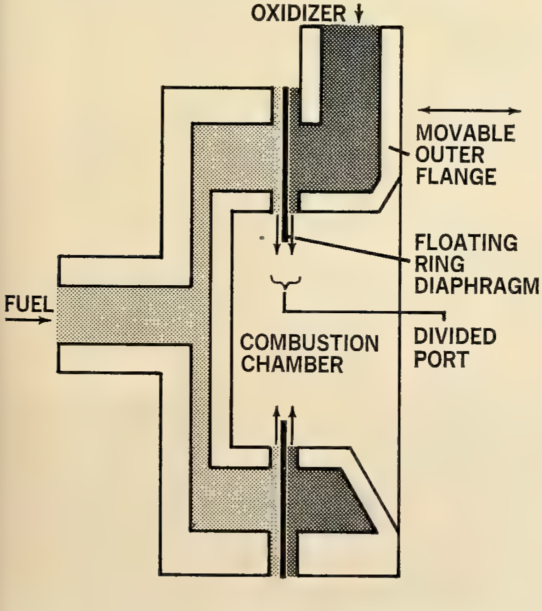
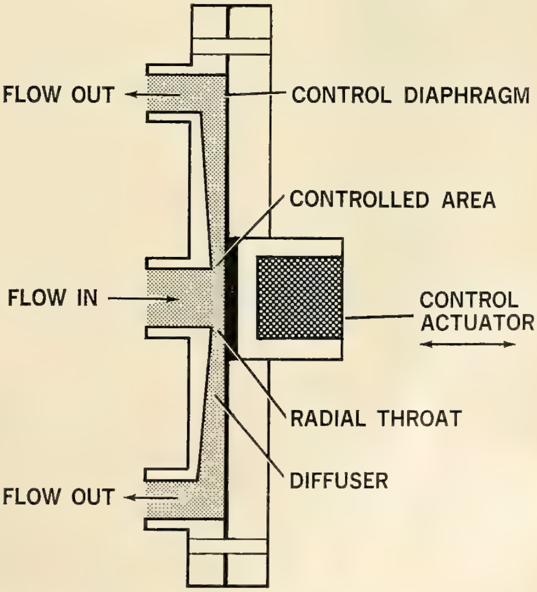


FIG. 2—Radially cavitating venturi controls mass flow.



their respective sides of the diaphragm after the upper flange is lifted a short distance away from the lower one by a worm gear. This permits control of the total flow by the slight turn of a rotor. This means of fuel injection was chosen to avoid some the temperature expansion problems that confound many injector-head designs, particularly those with controllable cross-sections.

• **Flow regulation**—Radially cavitating venturi nozzles were developed to regulate the mass flow. Fig. 2 shows a sketch of these control valves; the throat may be changed without stages, linearly, and without mobile gaskets. The inflow of the liquid is axial; it then passes through the throat and into a radial diffuser. Control is easy; it depends only on changing the lay of the metal diaphragm across the throat. A worm gear acting on the diaphragm would be one method of control.

Thus, by connecting the venturis and the injection head, a complete injection system is obtained. Mixture ratio is regulated by the venturis and the injection velocity is controlled by the cross-sections of the injector separated by the diaphragm.

• **Combustion experiments**—All combustion experiments were conducted with nitrogen tetroxide as an oxidizer and a mixture of 80% ammonia and 20% hydrazine as fuel. This fuel mixture was chosen for reasons of economy, since pure hydrazine would have been too expensive. However, the mixture was rendered hypergolic by the addition of metallic lithium to the ammonia.

Flow measurements could be conducted during this series of experiments based only on the characteristic curve of the venturis, which were calculated from water calibrations. The uncertainty of flow determinations was therefore high, about 5-8%.

Contents of the discharge tanks were weighed before and after each experiment to determine the mean specific impulse in the control range. "We were, therefore, unable to obtain a more exact estimate of the impulse," the experimenter reported.

For thrust measurements, the engine was mounted so that it fired onto a deflecting plate and scale. Scale movement was measured by strain gages.

Control of the experiments—that is, the constant adjustment of the venturis and the injection rotors—was carried out by hydraulic remote control. This permitted arbitrary setting of the thrust from the safety of the observation bunker, a few feet from the test area.

In all, a total of 18 combustion experiments of 3-12 sec. each were conducted with different thrusts. Because of the initial difficulties in hydraulic manipulation of the venturis, the first four experiments were not usable. The remaining combustion experiments showed an "extraordinarily sensitive and easily reproducible controllability at satisfactory to good combustion stability." The thrust control ratio achieved was 28:1.

As a result of his experiments, Kayser concluded that:

—The possibility of a thrust regulation of at least 20:1 with a radial diaphragm injection system was based on theory and proved experimentally.

—The control of the mixture ratio is necessary in this injection method and was achieved by a specially constructed type of venturi nozzle. These radially cavitating nozzles have, in contrast to the axially cavitating venturis, a loss factor almost constant with the control ratio.

—It was demonstrated that the mixture ratio of oxidizer to fuel can be controlled with automatic equality of the pressure drop across the injection cross-section of the oxidizer and fuel. This injection system, therefore, is suitable as a unit for use in rocket-ramjet engines as an autonomous flame holder in subsonic and supersonic combustion, and as an injection head in a stoichiometric operation. ■

How to Build a Test Facility with No Money

STUTTGART—A handful of students from the Stuttgart Institute of Technology one day in 1956 began shoveling dirt out of a barren spot belonging to Lauster & Co., stone masons. The hole, about 15 ft. deep and almost as wide, was dug within a few months; it included a small room at the bottom. The walls were laced with the masonry materials at hand.

Slowly equipment was moved in —amplifiers, oscilloscopes, seemingly miles of water pipe, a nozzle. Today, successors to the original group of students are completing nearly seven years of rocket research in the test-stand facility built in this hole in the ground.

The students were not interested in checking out textbooks on the theory of rocketry. They wanted to do their own research. As a result, they carried out investigations of special injection methods including a variable-area injector for continuous-thrust variation, of ablatively cooled thrust chambers, and of the hypergolization of ammonia and nitrogen tetroxide by adding metallic lithium to the ammonia.

Styling themselves the Study Group in Rocket and Space Technology, they placed several members in high places in German industry. Their present chairman, Lutz T. Kayser, proved the work of the facility through a research paper presented last fall at the International Astronautics Federation meeting in Warsaw, Poland.

The paper was acclaimed one of the best presented at the meeting. It was titled "A Radial, Diaphragm-Separated Injection Method for Variable-Thrust Liquid-Rocket Engines with or without Mixture-Ratio Variation."

• **The study group today**—The German students started with no money for their facility, only gifts from industry and mechanisms they could contrive themselves. Now, however, they are getting some financing from the university for special studies of interest to the establishment. Moreover, since 1962, the West German government has been paying the cost of fuels used and for a mechanic.

The organization, nevertheless, is still in control of the students, who pass it on from one group to another as new students arrive and others are graduated.

"We'd like more money, of course," Kayser told M/R here, "but not at the cost of our independence." He pointed out that the group makes not only technical analyses, in laying out its work, but also managerial and financial decisions. He also indicated the by-product technology the students get into—strain gage technology, acoustic measurements and so forth. They developed their own pressure transducers, measuring bridges, power amplifier and other components.

"If there had been a university lab, we would not have built our own," said Kayser. "The best way is to be independent of the university, but get some financial help on special investigations." He admitted that such support is now essential; otherwise the energies of the group would be totally spent raising money.

Probe Designed To Give Better Horizon Definition

by Charles D. LaFond

MINNEAPOLIS—A better means for determining horizon definition and measurement for spacecraft guidance and attitude control is the primary goal in NASA's first *Scanner* high-altitude probe expected to be launched this fall.

Under the $2-million program directed by Langley Research Center, the *Scanner* three-stage vehicle will be launched from Wallops Island, Va., into a 20-minute, 500-mile-high ballistic flight covering nearly 1,000 miles in distance before impact.

The third stage of the vehicle will carry an electro-optical attitude control system capable of holding the instrumented stage within 3 degrees of the local vertical for nearly 12 minutes during the peak portion of the ballistic flight path. This will permit the experimental package, containing a dual radiometer assembly, to measure infrared energy along the Earth's horizon but above the troposphere in an attempt to minimize cold-cloud problems that tend to degrade horizon-radiation measurements. Nearly the entire range from 14 to 40 microns will be scanned by the instrument package.

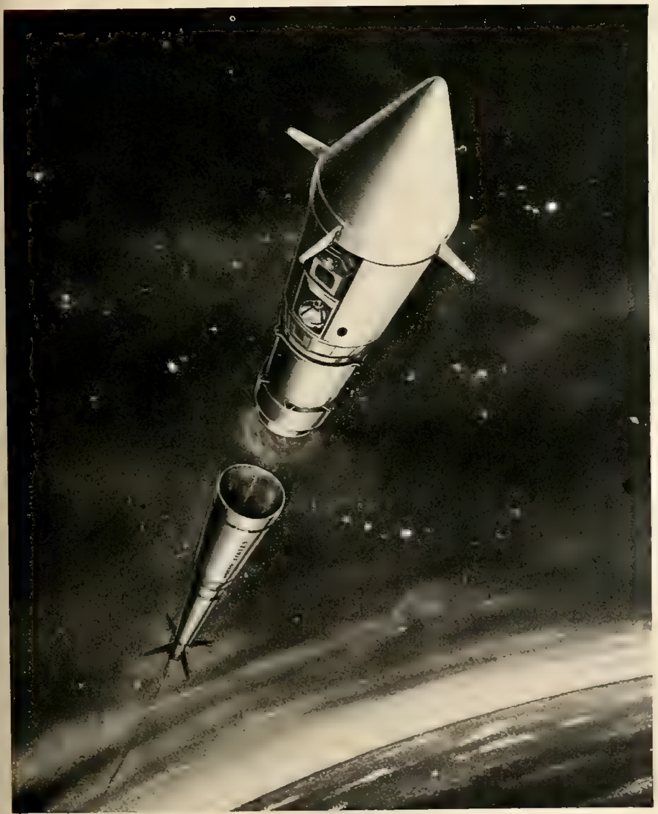
Under the program schedule, the second probe will be launched within three months of the first to obtain comparative seasonal data.

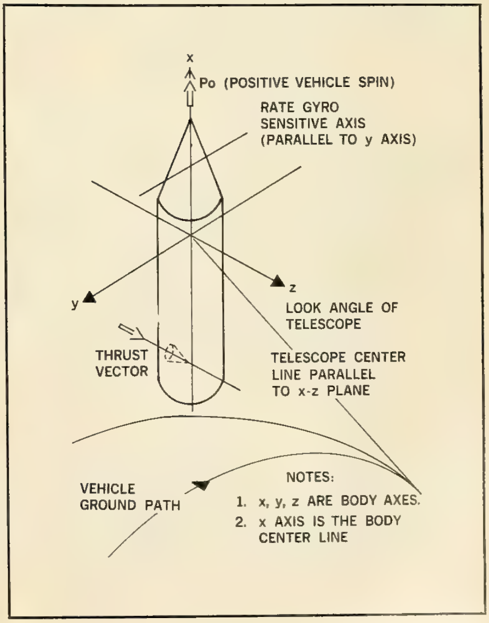
For the future, according to Howard J. Curfman, Jr., *Scanner* Program Manager, both Langley and NASA Headquarters are considering the possibility of employing similar IR measurement systems in a *Scanner* orbital vehicle. Also, there is a possibility that more *Scanner* high-altitude probes may be employed. Neither approach is currently funded, but, reportedly, the Fiscal 1966 budget request includes nominal funding for a *Scanner* orbiter feasibility study.

- **Vehicle configuration**—The first two vehicle stages will be provided and assembled with the third stage by Langley. First stage will be a Thiokol Castor XM-33 solid motor with two Thiokol Recruit XM-19's strapped on. Second stage will be a Thiokol TX-77 solid motor. The instrumented third stage will be provided with a Hercules Altair X-248 motor also added by Langley.

- **Instrumentation contractors**—Honeywell Aeronautical Div. in Minneapolis is prime contractor to Langley for attitude control system development and systems integration of the third stage. Under a $1.2-million contract awarded last June 29, the firm will build, test, and deliver three flight vehicles—two for launch and one backup.

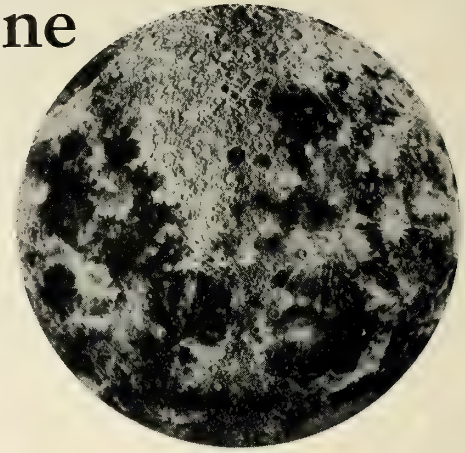
The principal experiment instrument assembly—for measurement of the horizon IR radiation gradients—is being developed by the Santa Barbara Research

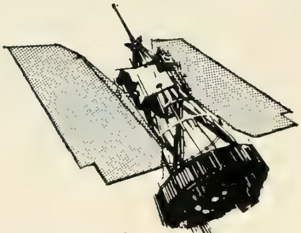



x
Po (POSITIVE VEHICLE SPIN)
RATE GYRO SENSITIVE AXIS (PARALLEL TO y AXIS)
y
z
LOOK ANGLE OF TELESCOPE
THRUST VECTOR
TELESCOPE CENTER LINE PARALLEL TO x-z PLANE
VEHICLE GROUND PATH
NOTES:
1. x, y, z ARE BODY AXES.
2. x AXIS IS THE BODY CENTER LINE

LEFT: Conception of Scanner probe as third-stage X-248 motor is ignited and separated from its shroud cover. Infrared instrument and attitude-control system ports open horizon to view. ABOVE: Vehicle attitude will be held to within three degrees of local vertical by a Honeywell-built attitude control system using a single reaction jet.

For more than 4-billion years there was only one earth satellite that never turned its back on us.





We made another one.

General Electric's Spacecraft Department designed, built and tested Nimbus — the world's largest weather satellite — for NASA. Launched August 28, 1964, it has carved out a lot of firsts. The first 24-hour television coverage of the entire earth by a weather satellite. The first pictures of the night-shrouded half of the earth. The first high power, earth-oriented spacecraft put into orbit. And a one-of-a-kind three-axis stabilization and control system which turns Nimbus full-face toward the earth at all times. Its testing program alone was unique — 88 days of the most severe tests undergone by any unmanned satellite built to date.

Now our emphasis is moving to other space efforts. We fully expect the same measure of success from each of the many current projects we're working on. General Electric's Spacecraft Department is the leader in studies of possible means of unmanned spacecraft exploration of planets of our solar system. For example — the early exploration of Mars (Mars 69-73). We are currently building the control and stabilization system for NASA's Orbiting Astronomical Observatory (OAO). We're expanding our efforts on gravity gradient spacecraft attitude control systems. Weightlessness, outer space travel, emergency ejection from orbit or spacecraft, and life support systems are other problems that are receiving careful attention.

Join us now.

Openings for Engineers and Scientists in: Guidance & Control Systems Analysis ☐ Electromechanical & Magnetic Components Design ☐ Orbit Dynamics ☐ Advanced Space Systems ☐ Weight Analysis ☐ Systems Project Engineering ☐ MHD Power Generation ☐ Continuum Mechanics ☐ Structures ☐ Program Cost Control ☐ Project Engineering ☐ Producibility Engineering ☐ Process Control ☐ Systems Engineering ☐ Guidance & Control Equipment Design ☐ Communications Systems Design ☐ Mechanical Equipment Design ☐ RF & Antenna Design ☐ Components Packaging Engineering.

You are invited to inquire further by writing to: Mr. J. S. Barson, Room 94-D, Spacecraft Dept., Valley Forge Space Technology Center, General Electric Co., P. O. Box 8555, Philadelphia, Pennsylvania. An equal opportunity employer.

MISSILE & SPACE DIVISION

GENERAL ELECTRIC

Center, a Hughes Aircraft Co. subsidiary, under a separate $621,150 NASA contract, but will be delivered to Honeywell for integration with the third stage subsystems.

A third NASA contract for $319,477 awarded to Baird Atomics, Inc., provides for development of starmapper assemblies used to correlate the radiometer measurements with respect to vehicle spatial attitude.

Weighing about 1,100 pounds, the payload stage will measure 12 ft. x 2 ft. in diameter.

First delivery by Honeywell will be to Wallops Station, Wallops Island, Va., this fall. There, final assembly with the other two stages and dynamic balancing will be performed and first flight is scheduled for late fall.

- **Flight sequence**—At 1.2 million ft. altitude, the *Scanner* third stage will be despun using a stretch yo-yo mechanism. At 1.25 million ft., the attitude control system will be activated. The ACS is designed to hold the vehicle within 3 degrees of the local vertical.

After vehicle stabilization the dual-radiometer operation will begin—still during the upward coast phase—and continue for 700 seconds. Measurement data will be telemetered to ground during this period. No recovery will be attempted after impact.

- **ACS configuration**—An IR horizon telescope, a rate gyro, a timer, and an unregulated-thrust cold-gas reaction-jet assembly comprise the attitude control system. Although being built by Honeywell, the approach is based on a 1964 development effort by Langley that proved the simplified ATC technique.

The timer initiates ACS operation four times during the flight.

The horizon telescope, being developed for Honeywell by Melpar, Inc., will employ two bolometers, one with a Sun shield. The two are connected in a bridge circuit. Radiation will be restricted by a filter to the 8-20 micron region. Field of view will be 16 x 5 degrees. A 0.75-cps vehicle rotation (after despin) provides a means for azimuth scanning.

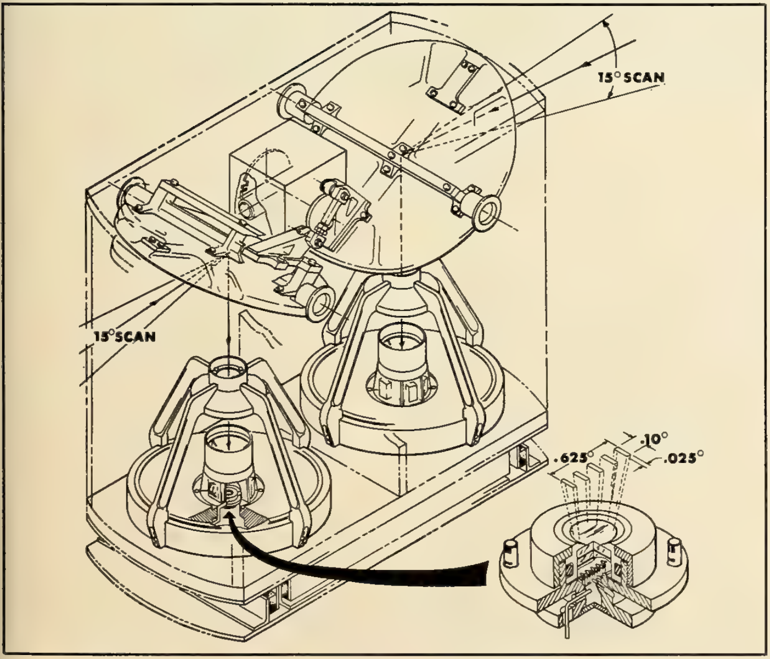
Output of the telescope bolometer is fed to an ac amplifier, thus eliminating dc inputs.

The shielded bolometer will be used to compensate for effects of temperature change on the active bolometer. Since the former provides an output reflecting only temperature and no radiation, it provides a means for output comparison against the active instrument output. Also, using common mode rejection techniques, the inactive bolometer can be used to compensate for bias-voltage variations.

With this approach to horizon measurement, it is believed that the "cold-cloud" problem (loss of horizon due to heavy cloud banks which tend to confuse IR measurement through false error signals) can be generally avoided.

The worst possible case, 180-degree solid horizon cloud cover, would confuse the ACS system, but *Scanner* launches can be made at a more opportune time to avoid such a situation.

SANTA BARBARA Research Center drawing shows the instrument and nutating configuration for the dual radiometer, the primary measurement instrumentation in NASA's Scanner probe.



A single reaction jet is employed in the ACS. The IR telescope/bolometer instrument and rate gyro determines compensation required and initiates attitude-correcting pulsed thrust.

The large field of view of the ACS telescope tends to average out cloud effects, thus providing simple but relatively accurate attitude control.

- **Experimental package**—The Baird-Atomic starmapper together with an angle encoder will be used to support the payload dual radiometer. It will provide measurements for telemetering to ground the angle between local vertical and the vehicle spin axis.

The instrument essentially is passive, consisting of a telescope fixed normal to vehicle spin axis. It is provided with a coded reticle at the telescope focal plane. The instrument has a 6 x 6 degree field of view. Designed to detect stars of 2.5 to 3 magnitude only, the starmapper scans with vehicle rotation and provides a steady pulse-train output for subsequent ground analysis to determine star location with respect to vehicle attitude.

The Santa Barbara Research dual radiometer will use a five-bolometer unit to obtain radiation measurements in the 14 to 16-micron (carbon dioxide) region and a similar instrument to cover the 20-40 micron range (water vapor).

Again, use of the vehicle spin will provide azimuth scan while a nutating mirror provides a 15-degree vertical scan for each radiometer.

Azimuth scanning rate is roughly 10 degrees per second.

A Motorola radar transponder, operating in the 5,400 to 5,900-mc range, will be used with ground trackers to provide accurate vehicle position and altitude measurements for correlation with the IR measurements.

Slant range will be determined within 3,000 ft.

An FM/FM telemetry system will be provided, operating in the 220-250-mc range and providing three separate RF links. Each will be triplexed through a common antenna. The two bolometer-series outputs from the dual radiometer, plus diagnostic and systems performance data, will account for two RF links; the third will carry only data from the starmapper. The latter outputs will directly modulate a transmitter (instead of being fed through a subcarrier oscillator as with the other two links) to obtain the full frequency response available for faithful reproductions of the pulse trains.

Three 5-watt transmitters will be used and three separate battery power packs provide power for all subsystems. ■

Use Foreseen for Surplus Minutemen

AF studies indicate ICBM's as boosters would provide valid environmental tests for future inertial guidance systems

Holloman AFB, N.M.—Wing I *Minuteman* ICBM's are likely to be used as Guidance Error Analysis Vehicles (GEAV), fired on snaking vertical trajectories over Cape Kennedy.

According to studies carried out at the Air Force Central Inertial Guidance Test Facility (CIGTF), surplus *Minuteman* boosters, when they become available, could represent the cheapest means to evaluate future inertial guidance systems in a true missile environment. CIGTF is making efforts to develop and acquire GEAV under project 671A.

To provide information about guidance system errors, the missile has to reverse its horizontal velocity vector a couple of times, while traveling only 50 mi. downrange. Payload would be recovered by air snatch, with water recovery as a back-up.

Limitations on *Minuteman* aerobatics, imposed in the interests of structural integrity, would not prevent gathering useful guidance error information. The limiting feature of the experiment is in the accuracy with which the Eastern Test Range can measure the missile's true velocity.

ETR was selected for GEAV because no other range can measure missile velocity in three axes to the required accuracy.

The ETR MISTRAM system is believed capable of the velocity accuracy needed, provided the missile flies a near vertical trajectory.

- **Velocity critical**—CIGTF is most interested in velocity information because velocity at burnout is the parameter most influential in controlling the point of missile impact. Chief technique in the GEAV experiments would be to compare velocities indicated by the inertial systems with those measured by MISTRAM.

Col. Charles E. Carson, deputy for guidance test, one of the two mission deputies at the Air Force Missile Development Center, Holloman AFB, sees GEAV as a logical extension of the work carried out at CIGTF.

He said "Our goal is to be able to take any system that comes in, and, either by components or systems, do complete laboratory tests on it. We then expand to the nearest thing you can get to an operational environment on the ground (by using the Holloman rocket sleds) and get the effects of velocity, vibration and acceleration. Then you should go into more operational conditions. And for a guidance system intended for a missile, this means you need a missile."

Carson said that future missile guidance systems will have to be evaluated more accurately than is possible on the present Holloman track. "We think we can refine present accuracies on the track," he said, "but this will not keep up with future accuracies that will be needed."

Missile guidance systems are now evaluated on the rocket-sled track and on operational *Minuteman* shots from Cape Kennedy. The disadvantage of the sled is that it does not simulate the operational environment completely. The disadvantage of the operational tests is that the trajectory used is designed to minimize error growth during flight, therefore it does not give results that allow separation of error coefficients.

The flight profiles selected for GEAV make error sources have significant effects, and enable their contributions to be separated. Basically this is gained by using higher accelerations for longer periods of time, extending the zero-g environment, and applying reverse accelerations. Vertical flights are needed to enable ground instruments to maintain adequate tracking accuracy.

- **Evolution**—The original concept for missile-borne tests was the Guidance Evaluation Missile (GEM). This was a two-stage vehicle (Algol IIA plus *Pershing* XB2) in which the second stage was mounted upside down. The payload was carried between the first and second stages.

Two main classes of trajectory were studied. In Type A, the first stage lifted the payload to 550,000 ft., then the second stage fired in the opposite direction. In Type B, the payload was allowed to coast up to an apogee of 1,300,000 ft. and the second stage was fired on the way down.

Main value of firing the second stage downward is that the acceleration reversal enables separation of the nonlinear error terms in the inertial system. Advantage of Type B trajectory is that 15 minutes of operation in free fall can be obtained.

When GEM was being studied about two years ago, no range was willing to claim an ability to meet the tracking accuracies required. As a result, some thought was given to installing new equipment at White Sands.

More recently, upgrading of tracking capabilities at ETR, restriction of GEAV firings to downrange distances of 50 mi. and some revision of guidance error models has led to acknowledgment of the feasibility of using the range.

The cost savings of not having to build a new tracking network are considerable. The further savings made possible by use of surplus Wing 1 *Minuteman* instead of a new vehicle, said a CIGTF spokesman, has led to "a lot of support now to use Wing 1 *Minuteman.*"

- **Flight profile**—The *Minuteman* would not be modified by turning the top stage around to fire downward. Instead, a reversal would be made in the horizontal velocity component during flight. The missile might climb steeply in a southeast direction, pitch over and fly horizontally toward the northwest, pitch up to fly nearly vertically southeast again, and then follow a ballistic trajectory to impact.

Lt. D. W. Henderson, CIGTF, said that a payload capable of carrying two inertial systems for test was desirable. The *Minuteman* guidance system itself would be re-programmed and located in the recoverable payload for further cost savings.

Original specifications called for a payload of 40 in. dia. with 1,000 to 1,500 lbs. total weight. Instruments under tests would weigh 250 to 500 lbs.

Supporting equipment in the payload would include power supplies, cooling, and telemetry, with a tape recorder for backup. ■

AIRCRAFT ENGINEERS

Douglas is expanding...
offers outstanding opportunities for you!

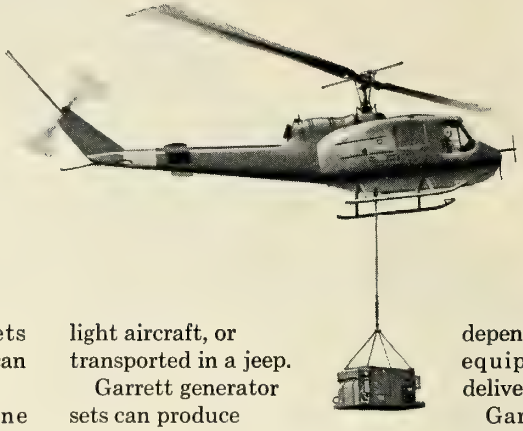
Douglas is humming with great new aircraft programs. Coming up are bigger, longer-range versions of the DC-8 jetliner and DC-8F jet freighter. Big things are happening on the new DC-9, which will double the places travelers can visit by jet. Also growing rapidly is a huge program on what will be the biggest jet transport in the world. In progress are military and commercial programs that will extend through the next decade and beyond.

Right now we are urgently seeking aircraft engineers with BS or advanced degrees who have experience in any of the following: Aerodynamics; Stress Analysis; Load Analysis; Dynamic Analysis; Electrical Design; Structural Design; Power Plant — Thermo-Mechanical; Flight Test Instrumentation; Flight Test Data Analysis; Reliability; Advanced Systems Engineering. Openings include a number of senior positions.

For full information, please send resume to Mr. C. B. Carrico, Professional Employment, Douglas Aircraft Company, 3855 Lakewood Boulevard, Long Beach, California. An equal opportunity employer.

DOUGLAS
AIRCRAFT DIVISION

What is the big advantage Garrett-AiResearch gas turbine generator sets have over diesel and gasoline engines? Mobility.



Lightweight generator sets made by Garrett-AiResearch can be moved fast.

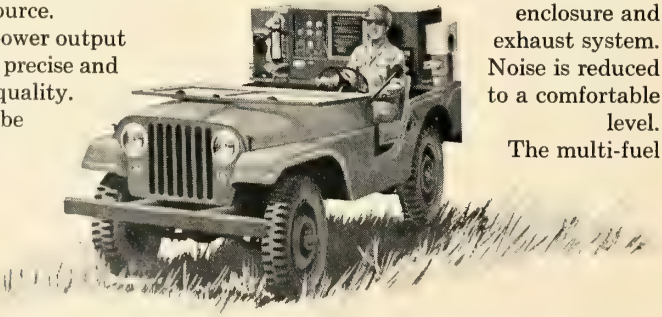
Heavy diesel and gasoline engines can't.

And *that* is one big reason why Garrett gas turbine generator sets are being specified more and more frequently in place of reciprocating engines.

Today, any modern weapons system – ground radar, missile support, or communications unit – must have the ability to move on a minute's notice.

That means it must be equipped with a lightweight, portable power source.

The power output must be precise and of high quality. It must be reliable.



Garrett gas turbine generator sets fill the bill on all counts.

For example, four men can easily carry a 20 kw or 30 kw generator set made by Garrett, or it can be airlifted by helicopter or light aircraft, or transported in a jeep.

Garrett generator sets can produce 50, 60 or 400-cycle electrical power or combination outputs ranging from 20 to 250 kilowatts.

Garrett sets are built tough – to withstand shock and rough handling in field operations.

Our sets operate reliably in any weather – with immediate starts from minus 65° to a plus 125°.

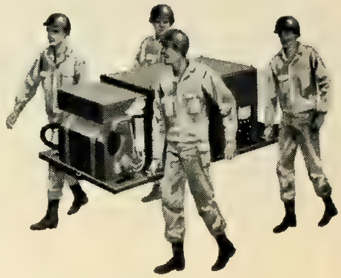
Starting, electrical loading, and shutdown functions are automatic.

Sound attenuation is an integral part of the enclosure and exhaust system. Noise is reduced to a comfortable level.

The multi-fuel capability of Garrett sets permits them to run on jet fuel, AV gas, diesel fuel, natural gas or commercial gasoline.

Because Garrett has built over 10,000 small gas turbines, proved dependability comes as standard equipment with every set we deliver.

Garrett-AiResearch generator sets are currently at work with many military units: The U.S. Air Force, U.S. Marine Corps, U.S. Navy, U.S. Army, NASA, as well as with foreign military groups.



For further information, write to J. A. Connell, AiResearch Manufacturing Division, 180 N. Aviation Boulevard, El Segundo, California.

Garrett *is* experience

AiResearch Manufacturing Divisions
Los Angeles • Phoenix

Circle No 8. on Subscriber Service Card

Mergers and Acquisitions

The Bunker-Ramo Corp. has absorbed Computer Dynamics Corp., a Silver Spring, Md., subsidiary of Teleregister Corp., a firm that consolidated with Bunker-Ramo last summer. CDC specializes in computer programming and management systems development. It becomes part of B-R's Defense Systems Div. . . . *Motorola, Inc., Phoenix, and Stewart-Warner Microcircuits, Inc., Sunnyvale, Calif., have reached an understanding whereby S-W will undertake manufacture of integrated circuitry similar to Motorola's emitter coupled logic series that Motorola sells under its "MECL" trademark. S-W's first circuits are to be available for evaluation during the first quarter of the year* . . . Aeronca Manufacturing Corp., Middletown, Ohio, has purchased the manufacturing equipment and various patents of Royan Corp. of Anaheim, Calif. Royan produces stainless steel honeycomb core for aerospace vehicles. . . . *United Shoe Machinery Corp., Boston, has agreed to purchase the business of Girder Process, Inc., Carlton Hill, N.J., a firm that manufactures a line of adhesives in film form for use in the defense, electronics, electrical, appliance and sporting goods industries.*

New Facilities

Pneudraulics, Inc., Montclair, Calif., producer of hydraulic and pneumatic components for missiles, aircraft and ground support equipment, has announced plans to expand its plant size from 6,000 to 15,000 sq. ft. The expansion will include installation of two new clean rooms. Some testing and production equipment will also be added . . . *Aerospace Chemical Systems, Inc., in conjunction with RDT&E Laboratories, has established a facility in Gardena, Calif., devoted exclusively to the reclamation and clean-room packaging of costly high-purity chemicals. According to ACS, the cost of returning contaminated chemicals to their original specification purity amounts to only a fraction of the original cost of the chemicals* . . . Adage, Inc., a manufacturer of data processing instrumentation, has relocated its Cambridge, Mass., plant to larger facilities in Boston. In addition to administrative and sales offices, research and manufacturing facilities, the new location will include a Signal Processing Center . . . *Texas Instruments' Metals & Controls, Inc., division has begun manufacturing operations in a new plant in Attleboro, Mass. The 22,000-sq.-ft., two-story building will be used in the production of basic components for KLIXON ® motor controls, relays, circuit breakers, switches and thermostats for the aerospace, appliance, electronics and heating and cooling industries* . . . Electronic Specialty Co. has broken ground in Los Angeles for a 70,000-sq.-ft. telemetry systems building. The new plant is designed specifically for the manufacture of large antennas, and will house the Kennedy Antenna Systems Dept. of the Electronics Div.-Los Angeles. The facility is scheduled for completion in July . . . *Fabri-Tek, Inc., magnetic core memory manufacturer has opened a new 6000-sq.-ft. plant in Ft. Washington, Pa. Product of the new facility will be ferrite memory cores.* . . . Associated Testing Laboratories, Inc., Wayne, N.J., has introduced a "rent-a-lab" plan whereby its environmental test chambers can be rented for periods of 30 to 90 days or more. A choice of high- and low-temperature chambers, as well as temperature-humidity chambers, is available with internal working volumes ranging from ½ cu. ft. to 27 cu. ft. Chambers utilizing both mechanical cascade and liquid CO_2 cooling systems are available.

ASME Stands Against Metric System

The American Society of Mechanical Engineers adopted a resolution at its 1964 Winter Annual Meeting to the effect that any legislative action directed toward adoption of an alternative system of standards, such as the metric, would not be in the best interest of the nation. Any such action, said ASME, would "be at this time confusing and disturbing to the productive capacity of the United States. . . ." Bills have been submitted in the Senate and House this session by Sen. Claiborne Pell (D-R.I.) and Rep. George P. Miller (D-Calif.) calling for a study of the pros and cons of such a conversion.

International

The Marconi Co. Chelmsford, Essex, England, has formed a Micro-Electronics Div. to exploit new techniques resulting from the company's research in the field of microelectronics. The new division will take over all responsibility for development, manufacture and sale of microelectronic devices, and will be responsible for providing a comprehensive design and advisory service. . . . *Andrew Corp., Chicago designers of antennas, antenna equipment and transmission lines, has opened a European office in Copenhagen, Denmark. The office is a move on Andrew's part to provide European customers with local assistance in systems engineering and product application.*

Engineer Salaries Up $1,000

Engineers' average salaries rose by about $1,000 over the last two years, according to a survey of the Engineering Manpower Commission. At the same time, salaries paid by the Federal Government generally have caught up with those paid by industry. According to a survey of more than 231,000 degree-holding engineers in one thousand organizations, the typical engineer now earns $11,325, compared with the typical engineer who earned $10,375 two years ago. This point is reached about nine years after baccalaureate. Median salary for an engineer in the Federal Government with 15 years experience in 1962 was $10,700, while industry paid $12,300. By 1964, the Government engineer and his industry counterpart both earned about $13,000, the EMC said.

contracts and procurements

AWARDS

AIR FORCE

$4,504,140—**Laboratory For Electronics, Inc.**, Boston, additional funding for production of AN/APN-131 Doppler navigation system components.

$3,085,000—**North American Aviation, Inc.**, Autonetics Div., Anaheim, Calif., first increment on contract estimated at $12,500,000 for modernization of the guidance and control ground equipment for the *Minuteman I* system.

$1,746,175—**Electronic Specialty Co.**, Los Angeles, for automatic tracking telemetry antennas.

$1,600,000—**Radiation, Inc.**, Melbourne, Fla., to manufacture signal-monitoring equipment.

$1,404,000—**Radio Corp. of America**, New York City, for management services in connection with the ballistic missile early-warning system.

$502,000—**Dynamics Corp. of America**, International Fermon Div., Suffern, N.Y., for the manufacture of power system modification kits.

$130,400—**Radio Corp. of America**, Systems Engineering Evaluation and Research, Moorestown, N.J., for a classified study.

$49,000—**Textron Electronics, Inc.**, MB Electronics Div., New Haven, Conn., to produce special Alinco electronic instruments for the Air Force Special Weapons Center, Kirtland AFB, N.M.

$48,410—**Sperry Rand Corp.**, Univac Div., St. Paul, Minn., for maintenance in support of the 437 launch vehicle computer system.

$32,825—**Lockheed Missile & Space Co.**, Sunnyvale, Calif., for *Lance* missile secondary injection thrust vector control study.

$31,260—**Arthur D. Little, Inc.**, Cambridge, Mass., for reciprocating cooling techniques for space based infrared sensors.

ARMY

$3,021,650—**Bell Aerospace Corp.**, Bell Aerosystems Co., Buffalo, N.Y., for modification of visual airborne target locator system AN/UVS-1.

$2,685,483—**Philco Corp.**, Aeronutronic Div., Newport Beach, Calif., modification to a previously awarded cost-plus-fixed-fee contract for *Pershing* missile study.

$2,500,000—**Dynalectron Corp.**, Washington, D.C. for services to be performed in the installation, operation and maintenance of government-owned data collection facilities at White Sands Missile Range, N.M.

$800,000—**Radio Corp. of America**, Aerospace Systems Div., Burlington, Mass., increase for the MTE program.

$798,000—**Radio Corp. of America**, Aerospace Systems Div., Burlington, Mass., increase for the DIMATE program.

$468,336—**Melpar, Inc.**, Falls Church, Va. for implementation of electromagnetic search, intercept and analysis system.

$164,999—**General Electric Co.**, Owensboro, Ky., to study transient radiation effects on microwave electron tubes.

$140,000—**Raytheon Co.**, Andover, Mass., for repair parts for *Hawk* missile.

$135,000—**Columbia University**, New York City, for basic research on an analysis of radar noise in *Nike* and related systems.

$126,588—**American Electronic Labs., Inc.**, Lansdale, Pa., for engineering development models of a VHF receiver.

$94,983—**General Electric Co.**, Syracuse, N.Y., for research leading to the design, development and fabrication of an ultra-high resolution cathode-ray tube.

$89,905—**The Franklin Institute**, Philadelphia, for services and materials for seven months to reduce, tabulate, plot, analyze and correlate data resulting from satellite communication experiments.

$74,130—**Babcock Electronics Corp.**, Costa Mesa, Calif., for target missile digital coder.

$69,511—**Sperry Rand Corp.**, Sperry Utah Div., Salt Lake City, for modification kits for *Sergeant* missiles.

$46,489—**Space Data Corp.**, Phoenix, to continue studies and perform a feasibility and design configuration study on families of rocket vehicles.

$42,891—**Thiokol Chemical Corp.**, Huntsville Div., Huntsville, Ala., for a two-month research study on high burning rate composite propellants; at Redstone Arsenal, Ala.

$27,000—**Motorola, Inc.**, Scottsdale, Ariz., for R&D to perform an additional study of the tracking technique of the AN/URQ-16 system.

NAVY

$13,042,000—**Hughes Aircraft Co.**, Culver City, Calif., for continued work on *Phoenix* air-to-air missiles.

$3,961,435—**General Dynamics Corp.**, Pomona, Calif., for continued work on *Terrier* and *Tartar*.

$2,900,000—**Sperry Rand Corp.**, Sperry Gyroscope Co. Div., Great Neck, N.Y. for two additional inertial navigation systems for use on *Apollo* tracking ships.

$1,579,689—**North American Aviation, Inc.**, Anaheim, Calif., for engineering services in connection with inertial navigation equipment.

$1,100,000—**Dynalectron Corp.**, Paradyn Div., Washington, D.C., for data processing and related technical work for the Fleet Missile Systems Analysis and Evaluation Group, Naval Ordnance Laboratory.

$282,000—**Sperry Rand Corp.**, Sperry Gyroscope Co. Div., Great Neck, N.Y. program definition phase contract for an improved sonar system.

$89,756—**Ling-Temco-Vought, Inc.** Vought Aeronautics Div., Dallas, for services and materials to conduct high speed sled tests.

$30,000—**Lear Siegler, Inc.**, Laser Systems Center, Ann Arbor, Mich., to build a complete ranging and bearing system for a laser device for field research and applications studies.

Martin Co. Orlando Div., Orlando Fla., for work on a universal shipboard weapon loader for handling of all missiles with which carrier-based aircraft are armed (amount undisclosed).

NASA

$1,700,000—**Radiation Inc.** Melbourne, Fla., for an Earth-space weather analysis system.

$432,641—**State University of Iowa**, Iowa City, for an electron and proton experiment.

$397,000—**Massachusetts Institute of Technology**, Cambridge, Mass., for a plasma probe experiment.

$350,000—**The Boeing Co.**, Aero-Space Div., Seattle, for a program to derive analytical model representation of the *Apollo* spacecraft and its launch vehicles.

$348,937—**F. B. MacLaren Co., Inc.**, Huntington Station, N.Y., for a docking simulator.

$343,400—**University of Michigan**, Ann Arbor, for instrumentation for radio astronomy experiment for the *OGO* program.

$220,654—**Computer Sciences Corp.**, El Segundo, Calif., for design and development of an off-line data processing system for *Pioneer*.

$124,000—**Technical Measurement Corp.**, Telemetrics, Inc., Santa Ana, Calif., for two Model 620 PCM decommutation systems.

$118,901—**Hughes Aircraft Co.**, Research Labs., Malibu, Calif., for ion thrustor electrode surface physics studies.

$64,300—**Honeywell, Inc.**, Minneapolis, Minn., for a study of fluid flight path control systems.

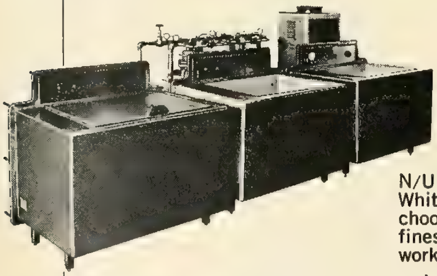
$49,990—**Honeywell, Inc.**, Aeronautical Div., Minneapolis, Minn., for an investigation to determine the use of rehearsal and warmup systems as aids to astronaut retention.

$49,253—**The Bendix Corp.**, Eclipse-Pioneer Div., Teterboro, N.J., for design, development, fabrication and delivery of two hybrid digital-to-analog comparator and converters.

$47,755—**Dynaplex Corp.**, Princeton, N.J., for ground data acquisition system.

$40,000—**University of Illinois**, Urbana, for investigation of the basic processes in gaseous plasma in various charge density and energy states.

HIGH RELIABILITY ULTRASONIC CLEANING SYSTEMS for ULTRA-CLEAN WHITE ROOMS



N/U "High Reliability" white room cleaning systems consistently perform day after day and component after component with the identical and desired cleaning results.

N/U gives you the widest range of White Room Cleaning Equipment to choose from . . . Made from the finest components by highly skilled workers.

- Lead Zirconate High Intensity Transducers, or Magnetostrictive Transducers
- Automatic Transistorized Generators
- Aqueous, "Freon" or Solvent Systems
- Recirculating Filter Systems

N/U "High Reliability" white room concept will effectively reduce the size and/or volumetric air requirements. They are sealed to the wall so that maintenance, solvent replenishment, filter change and maintenance are performed outside the white room without interrupting activities or contaminating the area.

N/U "High Reliability" White Room Systems have demonstrated their superiority. For further information write for Product Bulletins 162, 163, and 165.

NATIONAL ULTRASONIC CORPORATION
Ultrasonic Cleaning and Processing Equipment
James St., Somerville, New Jersey • Area Code 201 722-5200

Circle No. 9 on Subscriber Service Card

$32,073—**S. F. Manson Co., Inc.,** Arlington, Va., for further analysis of liquid cooled gas heat exchangers for segmented radiators plus change in contract completion date.

$26,482—**General Motors Corp.,** Defense Research Lab., Warren, Mich., to develop a new plasma diagnostic technique.

$13,936—**Aero Geo Astro Corp.,** Alexandria, Va., for development of an integrated maintainability maintenance documentation program for *Saturn* static power supply.

Union Carbide Corp., Carbon Products Div., New York City, for development of solar carbons for space simulation (amount undisclosed).

INDUSTRY

$2,000,000—**Borg-Warner Corp.,** Pesco Products Div., Bedford, Ohio, from **North American Aviation, Inc.,** Autonetics Div., Anaheim, Calif., for the construction of auxiliary hydraulic power supplies for the *Minuteman* ICBM.

Goodyear Aerospace Corp., Akron, Ohio, from **Sundstrand Corp.,** Denver, for design and development of a fuel tankage system for the new Mark 48 torpedo (amount undisclosed).

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Directorate of R&D Procurement
Systems Engineering Group (RTD)
Wright-Patterson AFB, Ohio 45433

Research to design, develop and fabricate an instrument for measuring nitrogen trifluoride in air. Requests for copies of this proposed procurement should be received not later than Jan. 31, 1965, in order to facilitate mailing of same to the extent copies are available. RFP 62174.

Purchase Dept.
Building 311-4
Naval Supply Center
Oakland, Calif., 94614

A contract will be negotiated with Radiation Research Associates, Fort Worth, Tex., for analytical and computation services to code and process nuclear radiation data and submit a report as to the results. Small business firms or others interested in subcontracting opportunities in connection with the described procurement should make direct contact with Radiation Research Associates.

Purchase Department
Building 311-4
Naval Supply Center
Oakland, Calif., 94614

A contract is being negotiated with the General Atomic Division of General Dynamics Corp. to continue an existing research program of chemical studies of radiation fall-out. Small business firms or others interested in subcontracting opportunities in connection with the described procurement should make direct contact with General Atomic. This notice does not solicit additional proposals but is issued for the benefit of prospective subcontractors.

Purchasing Officer
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

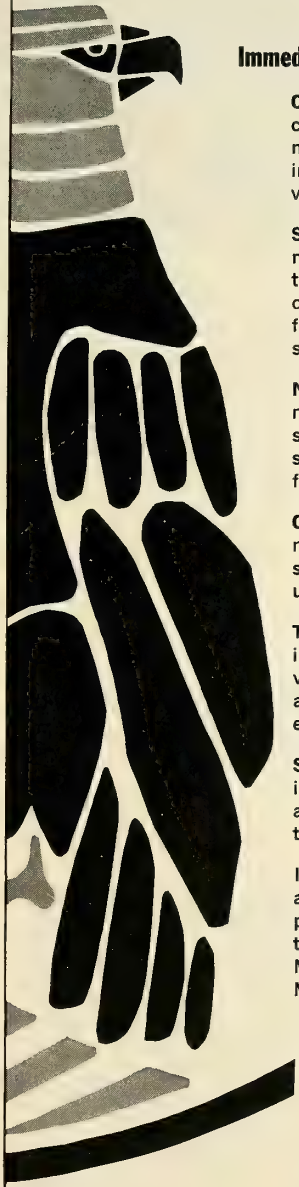
A contract will be negotiated with General Telephone and Electronics Laboratories, Bayside, N.Y. for an investigation of electro-optical techniques for controlling the direction of laser beams. For information only; RFP not available.

Directorate of R&D Procurement
Systems Engineering Group
Research and Technology Division
Wright-Patterson AFB, Ohio 45433

Negotiations will be conducted with Kollsman Instrument Corp., Elmhurst, N.Y., for an investigation of space position fixing techniques. For information only; RFP not available.

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, Calif. 94035

Nonpersonal services for operation of the 12-foot wind tunnel at Ames Research Center through June 30, 1965, with option to extend through fiscal years '66 and '67. RFP A-9733-(AC-17); due date Feb. 2, 1965.



MITRE NEEDS SYSTEMS MEN

MITRE works on the basic design and general system engineering of complex information, control, sensor, and communication systems for the United States Government. An important part of its mission is the development of new techniques in these areas and advancement of the general technology.

Immediate openings are available in:

COMMUNICATIONS — men with experience in communications systems for work on the engineering of communication networks, range instrumentation, tactical air control, and survivable communications.

SENSOR SYSTEMS AND TECHNIQUES — men needed to support theoretical and experimental programs on advanced radar and optical detection and tracking systems. Work includes feasibility and techniques analysis, systems synthesis and performance evaluation.

NATIONAL MILITARY COMMAND SYSTEM — men for systems analysis and feasibility studies, communications systems analysis, systems design, integration, and design verification.

COMPUTER PROGRAMMING TECHNIQUES — men with experience in the development and support of monitors, compilers, real time simulations, time sharing systems, etc.

TACTICAL SYSTEMS — men with experience in tactical, light-weight equipments for surveillance, communications, data processing and display . . . system test planning and evaluation and operations analysis.

SYSTEMS ANALYSIS — men with experience in military systems or operations analysis with a background in physics, mathematics, operations research, or industrial management.

If you have three or more years' experience and a degree in electronics, mathematics or physics, contact MITRE. Write in confidence to Vice President — Technical Operations, The MITRE Corp., Box 208G, Bedford, Mass. MITRE also has openings in Washington, D.C.

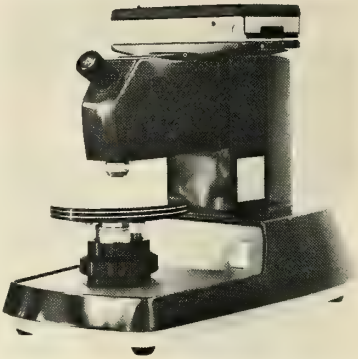
THE
MITRE
CORPORATION

An Equal Opportunity Employer

Pioneer in the design and development of command and control systems, MITRE was chartered in 1958 to serve only the United States Government. An independent nonprofit corporation, MITRE is technical advisor and systems engineer for the Electronic Systems Division of the Air Force Systems Command, and also serves the Department of Defense, and the Federal Aviation Agency.

Circle No. 10 on Subscriber Service Card

New Product of the Week: Multiple Beam Interferometer



The Model M100 angstrometer, designed specifically for measurement of absolute thicknesses of vacuum-deposited thin-films, is available from Sloan Instruments Corp. The device also finds application in examination of surface contours and other interferometric measurements.

In operation, the angstrometer passes the monochromatic light from a sodium vapor source through a wedge of air between a perfectly flat reference surface (Fizeau flat) and the specimen surface to be analyzed. A flat and smooth specimen surface will cause straight, parallel and precisely spaced interference lines to be generated in this air wedge. These fringe-lines are displayed in the field of view. Deviations as small as 40 Angstroms from flatness or smoothness will cause a deflection of these fringe-lines, which is measured and compared to the distance between fringe-lines to arrive at absolute measurements. Magnifications to 100,000 times are possible.

The instrument can be used in a brightly lit room, developers say, and is practically unaffected by normal environmental vibrations. The device has a sample stage that can micrometrically adjust to place the interference fringes in any desired orientation.

A built-in Polaroid camera and an adjustable Filar eyepiece are provided.

Circle No. 151 on Subscriber Service Card

Now Off the Shelf

STABILIZATION PLATFORMS & TRACKING SYSTEMS

For many years we have specialized in the design and manufacture of gimbaled systems for:
■ photographic & IR sensors ■ radar antennas ■ mirrors ■ gravimeters ■ star trackers ■ lasers ■ TV cameras ■ telescopes.

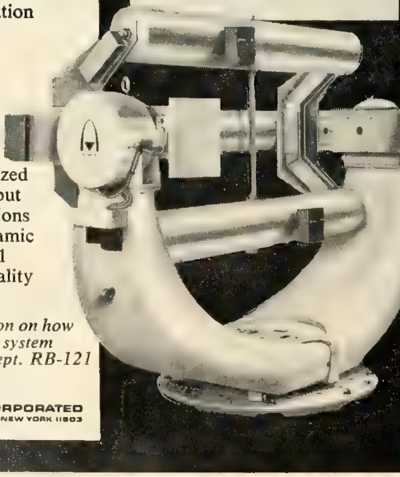
We are now in a position to offer off the shelf hardware and designs that will require a minimum of modification to accept your sensor. By manufacturing our own family of components, which include gyros, torquers, vibration isolators and data transmission devices, we are able to achieve:
■ residual motions of the stabilized load reduced to 0.1% of the input ■ verticality under flight conditions held to ±2 min. of arc ■ a dynamic tracking accuracy better than 1 min. of arc ■ gimbal orthogonality of 5 sec of arc.

Specifications For A Typical Airborne Unit
Orthogonality of axis—1 min. of arc.
In flight dynamic accuracy—
Azimuth ±.075°
Elevation ±.075°
Accommodates a 5½ foot dish.

For additional information on how we can meet your gimbal system requirements, write to Dept. RB-121

AEROFLEX LABORATORIES INCORPORATED
SOUTH SERVICE ROAD • PLAINVIEW • LONG ISLAND • NEW YORK 11803

Circle No. 11 on Subscriber Service Card



Bead-Probe Thermistors

General Electric Co. is marketing two bead-probe thermistors, designed for temperature measurement, control and compensation applications.

The units consist of a miniature bead thermistor hermetically sealed in a shock-resistant glass. They are available in 0.5 and 2-in. lengths with resistance values from 10,000 ohms to 1 megohm at 25°C and R_{25}/R_{125} resistance ratios from 35.0 to 51.5. Tinned dumet leads are weldable or solderable for ease of assembly. The units are rated for operation up to 400°C.

Circle No. 152 on Subscriber Service Card

Data Simulator

A communications data simulator capable of generating telegraph and high-speed data test signals has been developed by the Westrex Communications Div. of Litton Industries.

With the Model 954, test messages are generated externally by a punched paper tape reader or internally by an electronic test message unit. Up to 49% bias distortion can be introduced in the message.

The punched paper tape reader permits telegraphic transmission speeds up to 300 words/minute or eight-bit data speeds of up to 240 bits/second. The electronic unit has a fixed message that can be transmitted at speeds up to 2,400 BPS. Any 80-character test message may be generated by changing the electronic message unit. A combination punched paper tape reader and electronic test message unit also is available.

Circle No. 153 on Subscriber Service Card

Diode Laser Pulser

Seed Electronics Corp. has developed the Model H diode laser pulser, a high-peak-current, short-pulse instrument capable of peak currents in excess of 2,000 amperes in a 40-nanosec. pulse width.

The model employs a capacitance discharge circuit. The current wave form, however, approaches a square pulse. A rigid low-impedance coaxial line is supplied for accurate optical alignment of the diode in a dewar. The line is terminated by the diode to be modulated, in series with a 1-ohm current-sampling resistor. The voltage waveform across the sampling resistor is monitored by a 50-ohm line, which is returned to a BNC connector in the subchassis.

Specifications include a peak current of 100 to 2,000 amperes; rise time of 10 nanosecs., 10-90%; fall time of 15 nanosecs., 10-90%; repetition rate of 0 to 100 pps at 2,000 I_{pk} and 0 to 500 pps at 200 I_{pk}.

Circle No. 154 on Subscriber Service Card

Atmosphere Controller

Controlled atmosphere management is now possible with the automatic two-gas atmosphere controller manufactured by Space/Defense Corp. in several models. The device manages three atmospheric variables—total pressure, oxygen partial pressure and, by pressure difference, any inert gas such as helium or nitrogen.

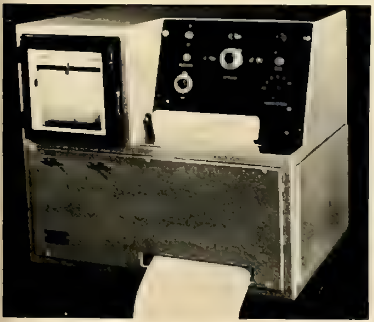
The controller can be changed to meet a new atmospheric requirement by turning the selector knobs; it has a broad control range that permits selection of numerous atmospheric combinations. Total pressure control can be maintained at any selected level from 150 to 800 mm Hg; oxygen partial pressure can be selected and managed at any value from 75 to 800 mm Hg. According to the manufacturer, its laboratory precision control maintains oxygen partial pressure to within 3 mm Hg and total pressure within 10 mm Hg.

The instrument is portable and weighs 9 lbs. Continuous and automatic management of a selected barogaseous atmosphere is provided for periods up to 90 days.

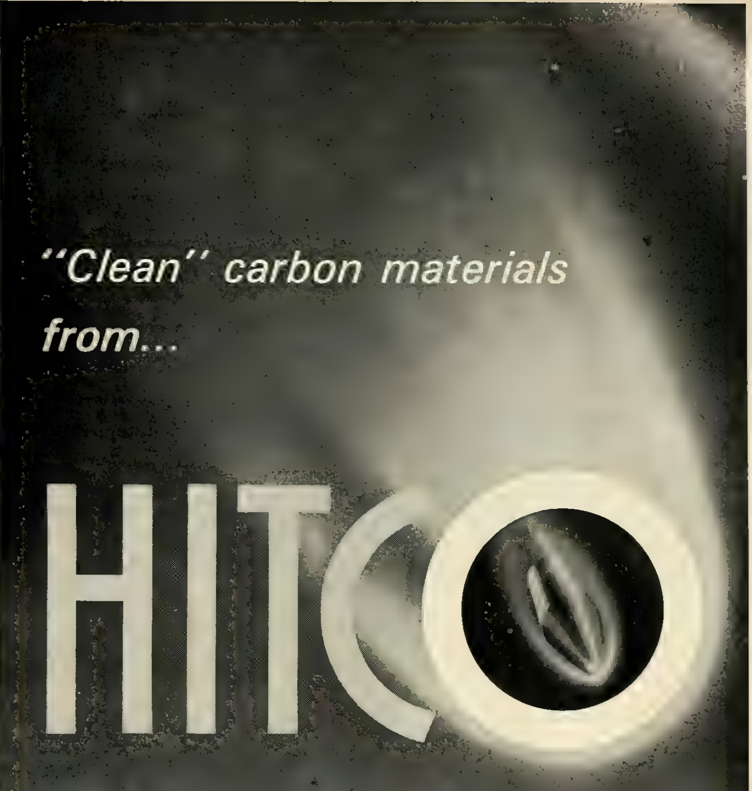
Circle No. 155 on Subscriber Service Card

Radiation Profile Recorder

The Numinco Corp. is marketing an alpha-beta radiation profile-recorder, manufactured by Caratom Corp., Paris.



The instrument provides measurement of the surface profile of material in sheet form, such as paper or plastics, weighing from 0.003 to 6 oz./sq. ft. A selection of five sample feed speeds and recorder speeds is available, providing a graphic presentation of variations in superficial weight around an indicated normal value. Either an alpha or a beta



REDUCE ION RELEASE ON RE-ENTRY

Clean ablation systems which assure minimal ion release provide a key penetration aid in helping high performance re-entry vehicles reach their targets. Clean systems can be guided more accurately because ion interference with controls is greatly reduced...and re-entry vehicles are safer from detection when tell-tale ion release is rigidly curtailed.

Purity and low thermal conductivity of materials are vital to ballistic missile penetration. HITCO's new version of CCA-1 carbon cloth—a low alkalinity carbon fabric designated CCA-1 (1641)—has a thermal conductivity of less than 6.5 K at a mean temperature of 300°F.

The total alkalinity content of this fabric is guaranteed not to exceed 400 parts per million, and its maximum sodium impurities do not exceed 150 parts per million.

HITCO is reducing the impurities of its superior CCA-1 (1641) ablative material even further. For details, write for HITCO Data File SA-2957-1.

HITCO®
H. I. THOMPSON FIBER GLASS CO.
1600 WEST 135TH STREET, GARDENA, CALIFORNIA

Circle No. 12 on Subscriber Service Card

ROCKETDYNE

Career Openings in Solid Propulsion

Rocketdyne's Solid Rocket Division in Central Texas offers outstanding opportunities to advance professionally in solid propulsion research, engineering, and production. Current major programs include Phoenix, Sparrow, Shrike, and Sidewinder.

Applied Mechanics

Conduct analyses in structural mechanics, mechanical shock and vibration, and viscoelastic stress, as related to solid rocket motors. Strong background in mathematics and one or more of above listed applied mechanics fields is necessary.

Ignition Systems

Conduct design, analysis, and development of solid rocket motor ignition systems.

Internal Ballistics

Conduct design and specification of solid rocket motor ballistic characteristics and charge design, plus analysis and evaluation of performance, using principles of thermodynamics, fluid mechanics, and stress analysis.

Value Control

Conduct value engineering analyses utilizing techniques predicated on past training and design experience, and direct organized teams in systematic cost reduction efforts as related to engineering product designs and associated criteria.

Reliability

Conduct reliability analyses and studies relative to solid propellant motor designs, and serve as senior reliability representative to specific program task teams and related special project activity.

Chemical Processing

Conduct design, analysis, and development of manufacturing processes associated with solid propellant propulsion systems.

Address inquiry or resume in confidence to:

Mr. D. A. Whayne
Professional Employment
Rocketdyne, Box 548
McGregor, Texas

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

North American Aviation
Rocketdyne Division

source may be used, depending on the thickness of the sample being measured. A precision of better than ±1% is guaranteed.

Circle No. 156 on Subscriber Service Card

Heat Exchanger

A 9,000-psig cryogenic heat exchanger is available from Hofman Laboratories, Inc.

The cooler is 9.75 in. in diameter and 34 in. high, excluding controls. It cools up to 21.7 lbs. of gaseous nitrogen per hour from 70° to —300°F on a continuous basis. As an alternate, it can also cool 3.1 lbs. of gaseous helium per hour from 70° to —300°F in one pass or to —400°F in two passes.

Both liquid nitrogen and liquid helium are used as refrigerants. The working pressure of gas coils is 9,000 psig, although coils have passed a rigid 14,000-psig hydrotest.

Circle No. 157 on Subscriber Service Card

Delay Line Tester

WMA andersen co., inc., has developed an instrument designed to test any delay line having a length of 1 to 18,000 microsecs. The "Uni-Pulse" features an integral trigger generator with a short-term stability of better than 1 part/million.

A pulsed RF output is provided covering the frequency range of 8.5 to 130 mc. In addition, video pulses and square waves are available. Either the RF or video pulse widths cover the range of 0.2 microsec. to 50% of the duty cycle. The pulsed RF output has a rise time of 40 nanosecs.; means are provided to degrade this rise time for special applications. An external trigger may also be employed when needed.

Circle No. 158 on Subscriber Service Card

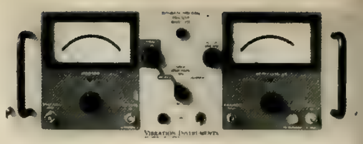
Hybrid Recorder

Techni-Rite Electronics, Inc., is marketing the two-in-one Ana-Vent recorder, designed especially for the aerospace industry. One half of the unit monitors up to 5 channels of analog information in the frequency range of dc to 150 cps. The other half monitors up to 36 channels of go/no go information. All information is recorded simultaneously side-by-side on a single chart, thus eliminating correlation errors.

Circle No. 159 on Subscriber Service Card

Tracking Analyzer

The Model 235 automatic tracking analyzer is a narrow-band, tracking wave analyzer for use in vibration testing of high-speed rotary equipment.



Developed by Vibration Instruments Co., the unit provides accurate direct readings of speed (RPM) and the amplitude (0-100 g's) of the fundamental frequency component of the test signal obtained from an appropriately placed accelerometer. The filtering is accomplished by quartz-crystal filters. A reference signal from an electrical speed pickup automatically phase-locks the analyzer to the fundamental angular frequency. The reference signal can vary in amplitude and waveform (distortion) with no effect on the filter characteristics.

The model also provides dc signal outputs for RPM and vibration level to facilitate continuous X-Y recordings of the fundamental frequency component of vibration versus speed. Tuning frequency range is 10 to 5,000 cps (or 600 to 300,000 RPM). Input is 120 watts at 115v, 50-60 cps.

Circle No. 160 on Subscriber Service Card

Diode Recovery Tester

A diode automatic recovery test set for use with a dual-channel sampling oscilloscope has been developed by General Applied Science Laboratories, Inc. The unit will automatically sort and measure both reverse or foward recovery time of nanosecond switching diodes.

The Model 450 offers automatic readout for the diode-recovery waveforms appearing on the screen. By introduction of the reference current level of the input, a "normalizing system" establishes accurate test results independent of the vertical displacement of the oscilloscope display.

Comparators and logic circuits provide for sorting into four separate bins.

Circle No. 161 on Subscriber Service Card

Capacitor Tester

The Model 801 capacitor analyst that tests capacitors in-circuit has been developed by B&K Manufacturing Co., a division of Dynascan Corp.

The unit tests electrolytic capacitors up to 2,000 mfd by a unique circuit, using a balanced bridge. It can predict life expectancy of any electrolytic capacitor rated 3v or more. A unique in-circuit leakage test eliminates need for disconnecting the capacitor from the circuit, the firm says. Test range is 25 pfd to 100 mfd. The model measures 5 x 8 x 12.5 in.

Circle No. 162 on Subscriber Service Card

WHO...WHAT...WHERE...

in the Missile/Space Industries!

SECTION B-2
COMPONENT MISSILE/SPACE MANUFACTURERS
SECTION D
...ILE/SPACE CONSULTANTS & SPECIAL SERVICES
SECTION B-1
MAJOR MISSILE/SPACE MANUFACTURERS
EXECUTIVE BRANCH
WORLD SPACE DIRECTORY

Fall/Winter 1964 Edition

17,000 KEY PERSONNEL IN 4,250 COMPANIES
NAMES—ADDRESSES—PRODUCTS—SERVICES
—MISSILE/SPACE REFERENCE MATERIAL—

No matter what you're looking for in missile/space, you'll find your first lead in the WORLD SPACE DIRECTORY. Whether you're interested in reaching key industry or defense executives, bidding on a government contract, planning research or production programs, sizing up competition, or looking for a job . . . the WORLD SPACE DIRECTORY is your primary source of information.

RETURN THIS COUPON

WORLD SPACE DIRECTORY
New Edition
Fall/Winter 1964
50% Revised

$12.50 per copy—U.S., Possessions, Canada; $13.50 all other countries

☐ Copies ☐ Bill me ☐ Bill Company

Name

Title/Position

Street **City** **State** Zip

Company Name

Division

1001 Vermont Avenue, N.W., Washington, D.C. 20005

RFI-EMC

Assignment: Involves theoretical and experimental development of suppression techniques from circuit to system level. Requires experience in RFI measurement and interference control techniques. Statistical correlation experience and knowledge of digital logic and circuits is desirable.

Location: These openings are at the Data Systems Division in Kingston, New York, approximately 100 miles north of New York City.

Please write: Outline your qualifications and interests to:

D. B. Calkins, Dept. 604A4
IBM Corporation
Box 390
Poughkeepsie, N. Y.

An Equal Opportunity Employer

IBM

MOVING?

let us move with you!

Six Weeks Is Required
To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

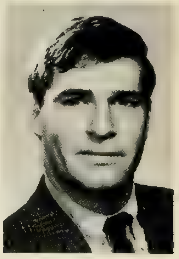
are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, **if possible, the address label from your last issue . . .** include your postal zone or zip number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

names in the news

McBRIDE


HOFFMAN

HOLT

SORENSEN

William D. McBride: Appointed Washington director of public relations for Martin Co., succeeding **Don P. Herron,** who was appointed assistant to the president of Martin. McBride has been with Martin since 1960.

Robert D. Murphy: Elected chairman of Corning Glass International, S. A. He was formerly president and is being succeeded in this office by **Forrest E. Behm,** formerly a vice president of Corning Glass Works. Behm also has been elected a director of Corning Glass International. **William H. Dana** has been elected assistant secretary of CGI. Also elected vice presidents at Corning were **Oakes Ames** and **James H. Bierer.**

Robert S. Stevenson: Elected chairman of Allis-Chalmers Manufacturing Co. He will continue as chief executive officer. Also elected was **Willis G. Scholl** as president, succeeding Stevenson. Scholl, who will be the company's chief operations officer, was previously executive vice president.

Dr. Paul R. Hoffman: Appointed director of materials technology at Avco Corp., Research and Advanced Development Division. He was formerly manager of the division's applications department.

John R. MacGregor: Elected president of the Society of Automotive Engineers for 1965. He is vice president and director of California Research Corp., subsidiary of Standard Oil Co. of California. Also elected were seven new members of the board of directors: **J. F. Adamson,** American Motors Corp.; **W. C. Arnold,** Koppers Co., Inc.; **H. F. Barr,** General Motors Corp.; **J. H. Famme,** General Dynamics/Convair; **Alex Gray,** Gray Forgings and Stampings, Ltd.; **W. M. Johnson,** Continental Oil Co.; and **J. W. Shank,** Chrysler Corp.

Oscar E. Holt: Appointed program manager on component programs with Thiokol Chemical Corp.'s Reaction Motors Division. He returned to RMD after being with Curtiss-Wright Corp. as director of quality control.

James S. Martin, Jr.: Named assistant project manager of the Lunar Orbiter Project at Langley Research Center, Hampton, Va. He was formerly manager of space systems requirements for Republic Aviation Corp.

Dr. Duane Williams: Joined Rocket Research Corp. as chief of systems analysis. He will be engaged in the development of the valveless rocket, a new control system for satellites.

Thomas C. Sorensen: Joined Aerojet-General Corp. as vice president of the International Technical Assistance and Development Co. He was formerly deputy director of the United States Information Agency.

Dr. George A. Downsbrough: Will join The Singer Co. as a vice president on Feb. 1. He will head the Technical Products Division and will also serve as general manager of Singer's Metric Division.

Dr. Bascom H. Caldwell: Named to head the General Electric Co.'s engineering education programs. He was responsible for the development of the *Nimbus* weather satellite and other similar operations at GE's Valley Forge, Pa., operation.

Francis M. Sherwin: Elected chairman of the board at The Brush Beryllium Co., succeeding **Bengt Kjellgren,** who resigned because of poor health. **H. Chapman Rose** was elected chairman of the executive committee of the board, succeeding Sherwin.

Edward M. Dougherty: Named to the board of directors of ARO, Inc., the company which manages, operates and maintains the Air Force's Arnold Engineering Development Center in Tennessee. He is also deputy managing director of ARO. **John C. Brandt** was elected assistant secretary.

Dr. Charles Stockman: Named to a sub-group of the Defense Industry Advisory Council by Deputy Secretary of Defense **Cyrus Vance.** He is technical director of B. F. Goodrich Aerospace and Defense Products Division.

Fordyce E. Tuttle: Elected to the board of directors of Operations Research Inc. He is also scientific advisor to the general management of Eastman Kodak Co. research laboratories.

Alan F. Dixon: Promoted to the newly-created post of manager of engineering for Raytheon Co.'s Semiconductor Operation. He will direct all engineering functions for silicon transistors, diodes, integrated circuits and field effect devices.

Advertisers' Index

AEROFLEX LABORATORIES INC. Agency—Groody Adv. Agency, Inc.	40
AiRESEARCH MFG. CO., THE GARRETT CORP. Agency—J. Walter Thompson Co.	36
AMERICAN OPTICAL CO., SPACE DEFENSE DIV. Agency—Fuller & Smith & Ross Inc.	2
CALMEC MFG. CORP. Agency—Schaeper Industrial Adv.	26
DEFENSE ELECTRONICS, INC. Agency—GLM Associates, Inc.	6
DOUGLAS AIRCRAFT CO., INC.	35
MISSILE & SPACE SYSTEMS DIV. Agency—J. Walter Thompson Co.	5
GENERAL ELECTRIC CO., SPACECRAFT DEPT. Agency—Deutsch & Shea, Inc.	32
GRAND BAHAMA PROPERTIES, LTD. Agency—Arthur R. Mogge, Inc.	45
HAWS DRINKING FAUCET CO. Agency—Pacific Adv. Staff	4
INTERNATIONAL BUSINESS MACHINES, FEDERAL SYSTEMS DIV. Agency—Benton & Bowles, Inc.	44
LEAR SIEGLER, INC., POWER EQUIPMENT DIV. Agency—Penn & Hamaker, Inc.	23
LING-TEMCO-VOUGHT, INC. Agency—Wyatt, Dunagan & Williams, Inc.	16
McDONNELL AIRCRAFT CORP. Agency—John Patrick Starrs, Inc.	47
THE MITRE CORP. Agency—The Bresnick Co., Inc.	39
NATIONAL ULTRASONIC CORP. Agency—Black-Russell-Morris	38
ROCKETDYNE, A DIV. OF NORTH AMERICAN AVIATION, INC. Agency—Batten, Barton, Durstine & Osborn, Inc.	42
TABER INSTRUMENT CORP. Agency—Harold Warner Adv., Inc.	9
H. I. THOMPSON FIBER GLASS CO. Agency—Getz & Sandborg Inc.	41
VITRO CORPORATION OF AMERICA Agency—Buchen Adv., Inc.	48

—when and where—

JANUARY

Symposium on Fundamental Phenomena in the Material Sciences, sponsored by the Ilikon Corp., Sheraton Plaza Hotel, Boston, Jan. 25-26.

Second Annual Aerospace Sciences Meeting, sponsored by the AIAA, New York Hilton, New York City, Jan. 25-27.

Joint Annual Meeting of the American Mathematical Society and the Mathematical Association of America, University of Colorado, Denver, Jan. 25-30.

Symposium on Environmental Sciences, sponsored by Northwestern University, Chicago campus and Pick-Congress Hotel, Chicago, Jan. 28-29.

Second Winter Power Meeting of the Institute of Electrical and Electronics Engineers, Statler-Hilton Hotel, New York City, Jan. 31-Feb. 5.

FEBRUARY

Sixth Annual Solid Propellant Rocket Conference, sponsored by the AIAA, Mayflower Hotel, Washington, D.C., Feb. 1-3.

Reinforced Plastics Division Conference, sponsored by the Society of the Plastics Industry, Edgewater Beach Hotel, Chicago, Feb. 2-4.

Winter Convention on Military Electronics, sponsored by the IEEE, Ambassador Hotel, Los Angeles, Feb. 3-5.

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Geneva, Switzerland—10 Rue Grenus; Geneva 321044

Paris, France—11 Rue Condorcet; TRU 15-39

YOUR OWN

PEACEFUL TROPICAL ISLAND PARADISE ON GRAND BAHAMA!

Just 50 miles (80.5 km) across the Gulfstream from Palm Beach, Florida, lies beautiful tropical GRAND BAHAMA ISLAND.

Become part of the social and community life in the fastest growing island in the Bahamas. Grand Bahama has three 500-room hotels and more building...luxury apartment blocks . . . churches, schools, stores, businesses...medical, dental and hospital facilities ...two championship golf courses ...casino...cinemas...marinas... world-famous fishing and skin diving...and booming industrial Freeport. Over 20 scheduled flights daily from Florida, plus steamer service. Adjacent to all this growth on Grand Bahama Island, we are offering a limited number of choice homesites.
Choose yours now!

HOMESITES: *From $75 down — $75 on closing (within 90 days) balance from $15 monthly on mortgage note.

*Will accept any currency at its official bank conversion rate

• NO LAND TAXES • NO BAHAMAS INHERITANCE TAXES • NO RESTRICTIONS ON PERMANENT RESIDENCE ON YOUR OWN LAND • NO CLOSING COSTS • FREE DEED • FREE TITLE INSURANCE •

AIR MAIL COUPON NOW!

SUNSHINE REALTY
777 Metropolitan Miami Building
Dept. MR-5 , Miami, Fla 33132
PLEASE SEND FULL INFORMATION

Name________________

Address________________

City________________

State__________Zip Code__________

Circle No. 13 on Subscriber Service Card

Much Ado About Little

THE BEST THAT CAN BE SAID of the controversial report on the aerospace industry just issued by Arthur D. Little, Inc., is that it certainly serves the best interests of Arthur D. Little.

Just how well it serves the interests of the industry which produces a considerable amount of income for Arthur D. Little is another question.

The management consulting firm was successful in attracting widespread attention to its report. Arthur D. Little is a highly regarded firm and its conclusion that the aerospace market is on a down-hill toboggan merits serious examination. We reported on the survey in last week's issue.

But we do not intend to let the survey conclusions stand unchallenged. We question both the conclusions and the company's decision to publish them.

The report was company-funded and unsolicited. The only logical answer as to why the survey was published, therefore, is that Arthur D. Little expected some benefit to Arthur D. Little. The conclusions fit such a standard. To eliminate any question about this, let us quote from the survey itself:

"Two weaknesses in the industry will require increased attention. First, because of a lack of management experience fully comparable to that in other diversified, technically based corporations outside the industry, aerospace companies' efforts to diversify into other products have been retarded; unless the industry adapts programs to acquire different kinds of management capabilities, attempts to convert major portions of companies to other kinds of activity will probably fail. The second weakness is that many companies are deficient in long-range planning and the market forecasts upon which it must be based. Part of this problem stems from the difficulty of analyzing the complex interactions between the elements of a company and between a company and its market."

Now let's guess what firm is incomparably suited to fill that lack of management experience and to analyze those complex interactions. Right. That fine old management consulting firm, Arthur D. Little.

If the future were not so dark and gloomy, if the industry were not faced with unfathomable and complex problems of diversifying out of aerospace work, the future of Arthur D. Little might not be so bright.

There is, without question, a changing pattern in this market. But we regard the future of the industry with optimism and its management capabilities with respect. It is no service to the industry to create such a wave of public pessimism without any cause other than one's own self-interest.

The survey warns ominously that production programs are declining and that all of the new space programs are essentially research and development work—"their end product being only a very few flight vehicles." This certainly is old-hat and hardly cause for financial alarm.

The report warns, again ominously, that since Fiscal 1960, the average number of major new production programs has been one a year, against an earlier average of from three to five. "Thus," says the voice of doom, "the number of major new production program opportunities for the industry has decreased 60-80% since 1960."

The comment on the number of new production starts conveniently ignores the industry's excellent financial health during this same period, as charted elsewhere in the report.

Other vital pieces of intelligence include the fact that there are 15 companies manufacturing spacesuits—"which works out roughly to one company for every two astronauts"—and that most of the funding for the *Polaris* missile has been accomplished—"this program will probably be essentially completed by the end of Fiscal 1966."

Just how any company management which based its planning on this last statement would regard the President's announcement last week of the $2-billion *B-3 (Poseidon)* program, we leave to those with less sensitive imaginations.

IF THIS WERE NOT A DYNAMIC INDUSTRY, we might indeed be concerned. Arthur D. Little tells us: "The aerospace industry clearly is no longer a growth industry. Aerospace companies must therefore accept the fact that they cannot reasonably expect to grow for the remainder of this decade. Their problem is not to stimulate growth, but to achieve stability."

This is a somewhat curious comment since the report earlier notes the "high degree of stability" of the major aerospace firms. But even more than that, it demonstrates a misunderstanding of the real strength of this industry.

The same sort of report might have been written about the airframe manufacturers ten years ago. Yet, those firms diversified themselves into a market which, as the Little report points out, grew by 75% in the 10-year period 1954-1963.

In the same way that the airframe manufacturers found new government markets while remaining dominant in the old one, we expect today's aerospace firms to continue to grow and prosper. As another management consulting firm, Corplan Associates, pointed out recently, advanced technology is spawning new industries and creating billions of dollars worth of business opportunities. Some of these new fields listed by Corplan include biomedical engineering, vacuum technology, engineered materials, oceanography, space simulation, electronic metalworking and waste product control and utilization.

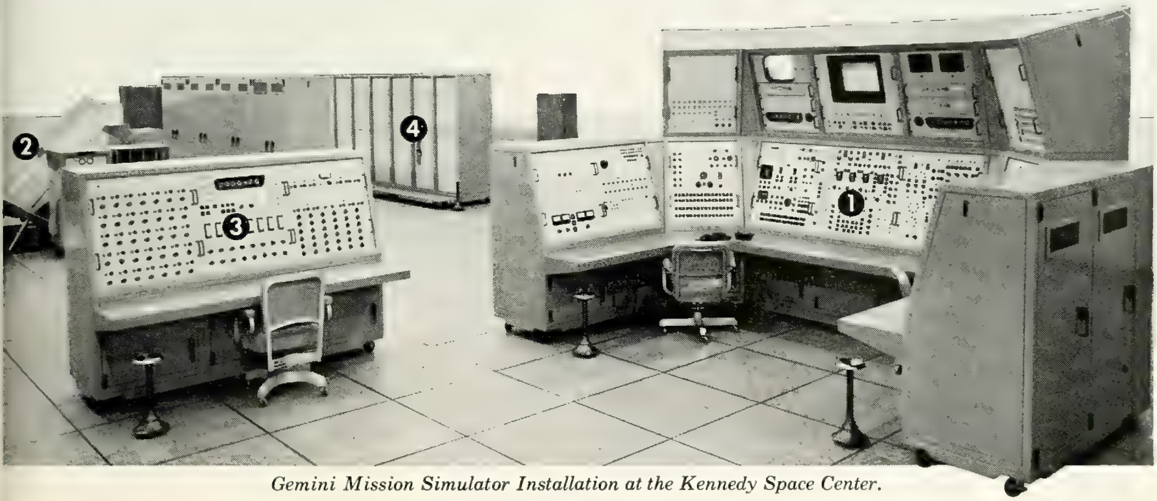
The drop in defense spending between the new fiscal year and the current one is expected to be $300 million—certainly not a major amount when discussing a $49-billion budget. The NASA budget again will be over $5 billion. Add new fields of interest to these and the future is bright for competent aerospace firms, regardless of unsolicited cries of doom from Cambridge, Mass.

William J. Coughlin

All You Add Is Weightlessness

The Gemini Mission Simulator precreates the sounds, circumstances, faults, smells, temperature conditions and instrument readings of a Gemini orbital rendezvous flight—with the exception of gravity effect.

Designed, developed, and produced for NASA's Manned Spacecraft Center by a McDonnell simulator team who fully understands the training problem and whose skills span many disciplines—celestial mechanics, kinematics, electronics, electrical and mechanical engineering, computer programming, engineering psychology, equipment design, and fabrication—the Gemini Mission Simulator makes possible integrated mission training for both flight crews and ground operations personnel.



Gemini Mission Simulator Installation at the Kennedy Space Center.

The **Instructors Station** ① permits monitoring of all instruments and controls and allows the introduction of flight control, environmental control, and communication systems malfunctions. It provides crew and instrument panel TV monitors, digital communications with the simulated onboard computer, and the capability for creating realistic noise and communication distortion.

The interior of the **Crew Station** ② is a visual and tactile duplicate of the Gemini Spacecraft cabin. The Crew Station is hydraulically mounted to tilt the cabin for crew comfort.

The **Telemetry Control Console** ③ enables telemetry processing, monitoring, and fault introduction, before transmission to the operational ground stations, as necessary for ground station operator training.

Peripheral Equipment ④ includes power supplies, audible noise generation equipment, communications subsystems, telemetry systems and other units external to the **Computer Complex** (not shown) which synthesizes the manual data insertion unit and the digital command system. All equipment is solid state and modular.

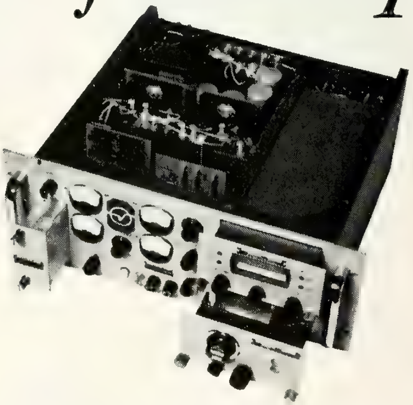
The Gemini Mission Simulator is one of the products and systems currently being provided by the McDonnell Electronic Equipment Division to industrial and military agencies in the fields of automatic check-out, simulation, training, guidance and control, and space communication. For a brochure describing "Skill in Electronics" at McDonnell, write:

MCDONNELL
ELECTRONIC EQUIPMENT DIVISION
DEPT. 946 • BOX 516 • ST. LOUIS, MISSOURI 63166

APPLYING ELECTRONICS AS AN INTERDISCIPLINARY SCIENCE

Circle No. 14 on Subscriber Service Card

This is Vitro Electronics' Telemetry Receiver · It is Type 1037A · It is not new It is thoroughly field-proven · It is in its fifth production run · It is the standard for comparison



The 1037A is still the only advanced type telemetry receiver that is in full production with a long and successful history of field-proven performance and reliability. The 1037A offers a wide choice of off-the-shelf plug-in RF tuners covering a range of 55-2300 mc and the most versatile group of IF demodulators available which include true phase with long or short loop, linear phase for special PCM applications, phase tracking, high capture ratio, phase lock, FM and AM for all known telemetry formats. Integral plug-in predetection converters and spectrum display units optional. Improved adjacent channel rejection and optimum combination of RF nuvistors and solid state design avoid the dynamic range problems inherent in solid state RF tuner designs.

Vitro Electronics is also the only manufacturer with a complete line of off-the-shelf solid state pre- and post detection combiners, dual diversity receivers, up and down converters, multicouplers, preamplifiers, etc.

For a complete new catalog or additional details please write to
Vitro Electronics, 919 Jesup-Blair Drive, Silver Spring, Maryland.
VITRO CORPORATION OF AMERICA · 90 PARK AVENUE · NEW YORK, N.Y. 10016

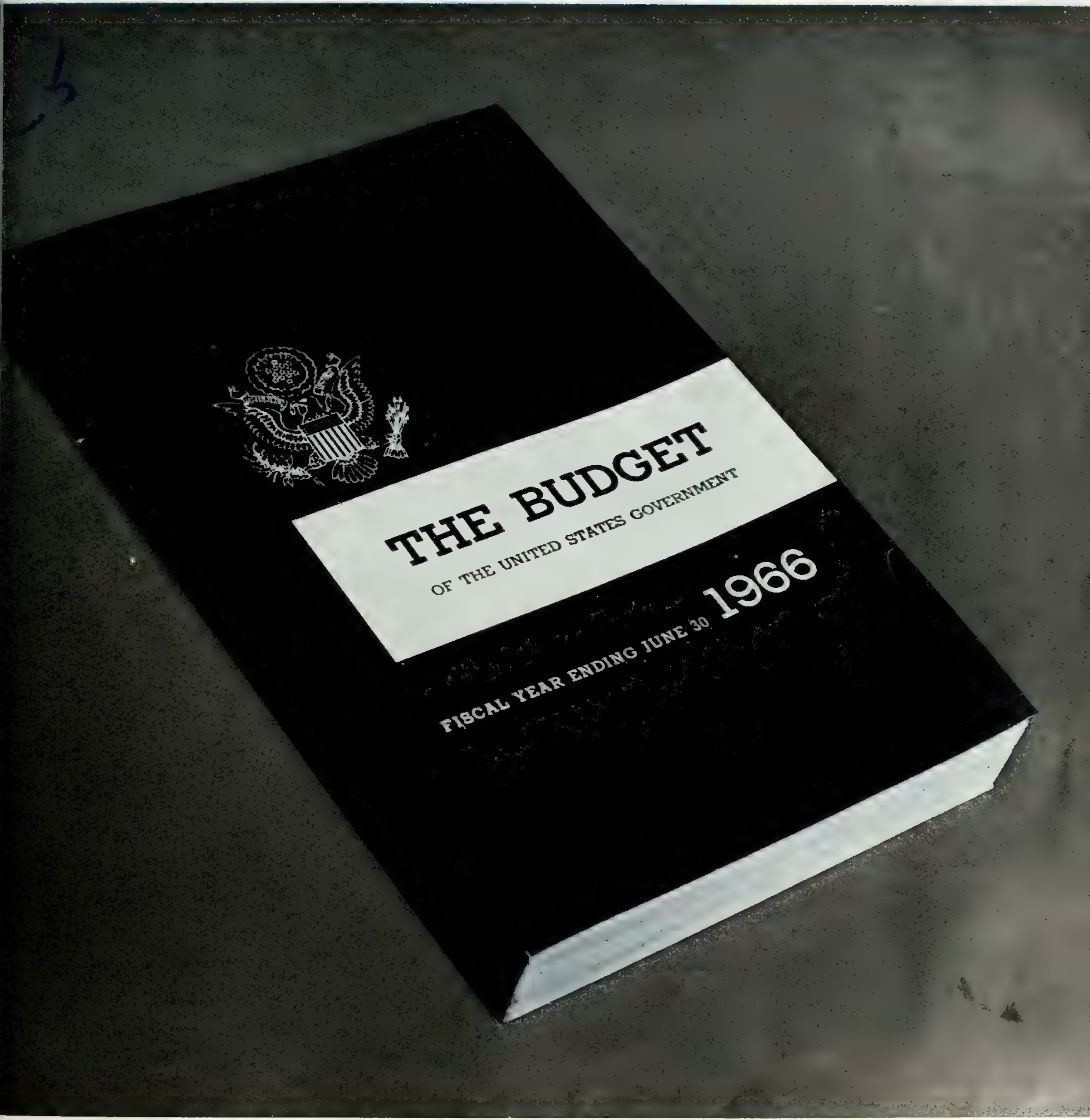
Vitro

Circle No. 15 on Subscriber Service Card

FEBRUARY 1, 1965

missiles and rockets

HE WEEKLY OF ADVANCED TECHNOLOGY


THE BUDGET
OF THE UNITED STATES GOVERNMENT
FISCAL YEAR ENDING JUNE 30 1966

Copy of the FY 1966 Budget—Space Spending Up

SPECIAL REPORT ON THE BUDGET

AN AMERICAN AVIATION PUBLICATION

MODS
MTSS
LORL
SLOMAR
OSSS
SMART
PSBLS
OLO
MOL
AORL
FOR VALUE
EVALUATE
SPERRY
MORL
GSS
AOLO
NOSS

You name it. Sperry is ready, willing and able to provide the guidance, control, data management, communications—or complete avionics package—that will help insure the success of the mission. ☐ Sperry is no stranger to space needs. Accelerometers for Apollo/LEM guidance . . . stabilization control studies of space stations for NASA's Langley Research Center . . . miniature inertial components for satellite control . . . equipping USAF's new global Range Control Center at Cape Kennedy . . . energy management and control of re-entry vehicles . . . Gemini and Apollo beacons . . . these are just a few of our involvements. We're deep in control subsystems for orbiting vehicles . . . gravity, zero gravity stabilization . . . precision aerospace guidance and control. So whatever the project, insure the avionics—with Sperry. **General Offices: Great Neck, New York.**

SPERRY
DIVISIONS OF
SPERRY RAND
CORPORATION

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY
Volume 16, Number 5 February 1, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors
Charles D. LaFond................Electronics
William S. Beller................Engineering

Associate Editors
Lawrence J. Curran......Assistant Managing Editor
Heather M. David..................Space Medicine
Michael Getler........................Electronics
Russell Hawkes..........................Industry
John F. Judge..................Advanced Materials
Robert L. Parker.......................Copy Editor
Rex Pay.............................Electronics
Hal Taylor................................NASA
James Trainor..........................Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach..................Art Director
Donald Strickland............Assistant Art Director
Suzanne Montgomery............Editorial Assistant
Sally Fosnight..................Editorial Assistant

BUREAUS
LOS ANGELES.....9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks..................Bureau Chief
NEW YORK...................20 East 46th Street
Michael Getler
CAPE KENNEDY................507 Orange Ave.
Chris Butler....................Merritt Is., Fla.
MIDWEST..........................423 N. Quentin
John L. Zimmerman..............Wichita, Kan.
PARIS..........................11 Rue Condorcet
Jean-Marie Riche
GENEVA............................10 Rue Grenus
Frank G. McGuire

EDITORIAL ADVISORY BOARD
Dr. Peter Castruccio Alexander Satin
Conrad H. Hoeppner Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton............National Sales Manager
Paul B. Kinney........Eastern Advertising Manager
Edwin J. Denker, Jr......Western Advertising Manager
Kenneth C. Blanchard.Marketing & Research Director
John N. Carlin...............Director of Circulation
Paddy Nelson.................Circulation Promotion
R. Virgil Parker............Director of Production
Barbara Wiener........Advertising Services Manager

Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President.......................Wayne W. Parrish
Senior Vice President..............Louis C. James
Vice President.....................Fred S. Hunter

THE COVER

President Johnson's Fiscal Year 1966 budget document, which went to Congress Jan. 25. Administration request for the defense and space industry totals $23.7 billion, down slightly from Fiscal Year 1965 funding. M/R's detailed, illustrated report begins on p. 10.

FEBRUARY 1 HEADLINES

Lockheed Fires Gemini's Agena Target Vehicle 8
START System Detailed in LBJ Report to Congress 8
Comsat, Hughes To Start Work on Military System 8
Lockheed, Thiokol Awarded Big Solids Contracts 8

FY '66 MISSILE/SPACE BUDGET REPORT—

New Obligational Authority Set at $23.7 Billion 10

SPACE POWER

Sperry Farragut Develops Brushless DC Motor 22

SPACE SUPPORT

Artificial 'Nose' May Find Space Application 26

SPACE ELECTRONICS

Military Interested in New Burroughs Computer 28
System To Consolidate White Sands Missile Control 32

DEPARTMENTS

Letters 4
The Countdown 7
The Missile/Space Week® 8
Technical Countdown 21
Products & Processes 34
The Industry Week 41
Contracts/Procurements 43
Names in the News 44
When & Where 45
Editorial 46

48,600 copies this issue

moon

For centuries it has beckoned man. Now we are helping go there, to the moon and beyond. At Brown Engineering Company, located in the Space Capital of the Nation, Huntsville, Alabama, the professional aerospace engineers and technicians do the never-done while participating in man's most fascinating adventure, the conquest of space.

STRUCTURAL DYNAMICS ENGINEERS: with exceptional abilities are invited to investigate opportunities with the SPACE VEHICLE DIVISION of BROWN ENGINEERING COMPANY, INC. B.S. or M.S. Degree in Engineering or Physics with 2 - 10 years experience in vibration, shock, acoustics, dynamic loads, flutter, or Aeroelasticity.

OPPORTUNITY FOR YOU: An established mission support contractor to the Marshall Flight Center and Saturn Launch Vehicle Program, Brown's entry into new endeavors and the continuing growth of the space program points to unparalleled opportunities for advancement, security, and an overall bright future at Brown.

EXCELLENT LIVING CONDITIONS AND RECREATION: Huntsville is a cosmopolitan city of 120,000 with suburban atmosphere. Fine housing is available in modern apartments of picturesque residential areas on the city's slopes and in the valleys. Giant modern shopping complexes serve you, and overall living costs are low. Located in the TVA lake region, swimming, water skiing, fishing and hunting areas are close at hand. Art, music, theater, and other culture groups are active throughout the city.

EDUCATION: Huntsville has one of the Southeast's most modern public school systems, offering equal education opportunity to all. Higher education is available through the University of Alabama, Huntsville Campus, a fully accredited four-year college offering undergraduate and graduate degrees in engineering and related aerospace sciences in day and evening programs.

BE WITH THE MEN WHO ARE THERE: Join them, the imagineers, the 3,000 strong there at one of the leading aerospace engineering organizations in the country. Be with the men who are there, there at Brown in Huntsville. Here are top working conditions, living conditions, growing conditions. Go with Brown. Grow with Brown.

Submit Your Resume in Confidence to: William A. Giardini, Vice President and Manager of the Space Vehicle Division.

BROWN
ENGINEERING COMPANY, INC.
300 Sparkman Drive, N.W.
Huntsville, Alabama 35807
An Equal Opportunity Employer

letters

Lots of Room at the Top

To the Editor:

I have been intrigued and, yet, perplexed by the whirlwind of justifications, apologies, denunciations, explanations and the like which surround the military mission in space and the *MOL* vs. *MORL* controversy. Perhaps the principals themselves are a little confused as to just what their positions are, or should be. Perhaps I may offer a personal opinion.

First, I believe that almost all concerned should realize that there is a need for *both* the military and the civilian in space. *Terra firma* (or at least the United States) is a good example of the two working together, yet on different aspects of the world's problems—the military maintain order and defend the country from aggression, while the civilians support the economy and generally work to improve their way of life. Only under very extreme circumstances would the civilians wish to take over the defense and related functions of the military, and certainly few people would endorse the mobilization of the entire nation, with every man, woman and child in uniform. So it is with space. Let one defend, and the other make productive use of.

One might consider the Air Force as uniquely qualified to travel and observe, and to transport men and their equipment quickly and easily to wherever they are needed—always returning to a fixed base of operations at the end of a mission. We call upon them to transport civilian as well as military goods and personnel when the occasion arises. In addition, it is assumed that such research as is undertaken by the Air Force (or any military service) is primarily intended to increase their efficiency and capabilities in the defense of the nation.

As such, I should think that the Air Force has a very significant role in space —not in attempting to monopolize the whole effort through military space stations and the like, but in expanding their present duties. Let the Air Force develop reconnaissance and offensive manned spacecraft, capable of ranging far and wide to deter aggression—just as do the B-52's, the B-58's, etc. Ground-launched orbital glide interceptors would soon be followed by true aerospace planes, capable of winged flight in the atmosphere and true rocket flight in space. Later, military orbiting space stations would be developed, but would confine themselves primarily to military functions, *not* research and exploitation of space, which is a civilian function. In addition, the military-piloted craft could provide ferry service to the civilian space stations and observatories. Certainly these tasks and others will provide a tremendous and worthwhile challenge.

The first orbital laboratories and stations should, in my estimation, be civilian. I very much fear that a military program with its security restrictions and the like would essentially freeze out any scientific programs by non-military parties. (How long has it been since the Air Force has discussed any of the launches conducted at Vandenberg—some of which were probably of great interest to the scientific community?) The two programs, civilian and military space stations, should be regarded as *both* essential and, as such, independent.

NASA has shown some reluctance to undertake the orbital station task, principally (I imagine) because of the herculean tasks still ahead in the manned lunar landing program. Yes, but . . . The Manned Spacecraft Center is and will be extremely busy with the *Apollo* program for some time to come, and certainly would be unwilling to undertake a second major program just now. Agreed! But there is another NASA center uniquely qualified in this area—MSFC, in Huntsville. The techniques and skills which have gone into the development of the massive *Saturn* class of launch vehicles should certainly be applicable to such a task. In addition, there would be much less effect on the *Apollo* program, since the actual task of fabricating the launch vehicles for the lunar program is, or will soon be, entrusted to private industry. And, since the engineers at Huntsville are thoroughly acquainted with the design and details of the launch vehicles which would be utilized, problems of integration and of vehicle/station interface will be minimal.

There is a place in space for both the Navy and Army as well, although their participation must be delayed a time. The Navy, with its experience with submarines and warships, appears the logical choice for future deep space missions wherein small groups must function within an essentially closed ecology for long periods of time. Similarly, the Army (and its Corps of Engineers) would appear the logical choice for the establishment and maintenance of outposts on the Moon or such planets as may warrant manned bases.

Lastly, I regret the fact that many people seem unwilling to spend funds for the conquest of space, preferring more immediate (or more personal) gain. Columbus could certainly have given up in despair, yet the world is richer for the fact that he attempted the unknown . . . and won!

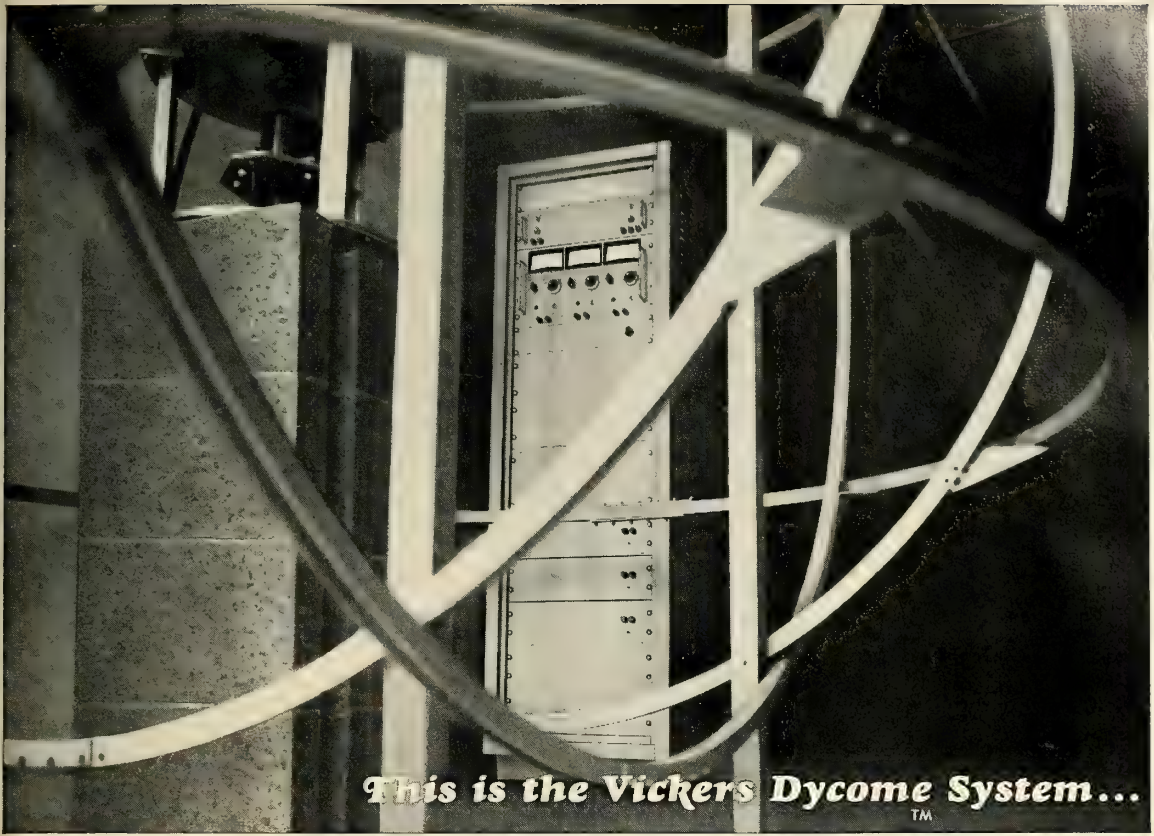
David Winslow
Huntsville, Ala.

Soviet Chemistry

To the Editor:

Please accept my congratulations on your Jan. 11 editorial ("Paper Bear"). Your remarks on the status of the chemical industry in the Soviet Union are perfectly correct. Let me add an item which you omitted. Before stepping down, Mr. Khrushchev announced that the Soviet Union must and will develop a strong chemical industry which, as he announced, is poorly developed. As the main reason, he mentioned the lack of fertilizer for agricultural purposes. The agreement with your conclusions is a perfect one.

M. Z. v. Krzywoblocki
Professor—Space Seminar
Michigan State University
East Lansing, Mich.



It is the first standard Dynamic Control Magnetic Environment System.
It will provide a constant, precise and uniform field of any desired magnitude.
It will also maintain a zero magnetic field in any location.
It does not require a shielded room.

The Vickers Dycome is a practical solution to the problems inherent to the control of natural and man-made magnetic fields. And because it's a "production run" system, it is realistically priced.

It consists of:

A 3-axis Helmholtz Coil, eight feet in diameter.

A 3-axis, flux-gate magnetometer probe assembly.

A control console that contains all necessary power supplies, magnetometer amplifiers, field adjustment controls, field indication meters and gradient adjustments.

You can install the Dycome System almost anywhere. (In Times Square or along a Los Angeles freeway, if need be.) It will automatically compensate for changes in ambient field disturbances. As we say, it's dynamic. Its solid state feedback circuitry provides minimum drift operation.

This completely static system is highly reliable, uses semiconductor electronics to increase accuracy while decreasing system noises, is simple to operate, and is adaptable to both manual and automatic programming. And it has these performance characteristics:

Accuracy: The field in the working volume will not deviate from the set point by more than 2.0 milligauss for variation in the ambient magnetic field of up to ± 600 milligauss. Deviations are proportionally lower with smaller ambient field disturbances.

Response: 3 db down at 10 cps.

Controlled Field Uniformity: (Nominal factory environment) Sphere, 0.5 foot diameter, within 0.6 milligauss.

Sphere, 2 foot diameter, within 6.0 milligauss.

Field Control Range: +600 milligauss to —600 milligauss.

Meters: Field Indication Meter, +1.0 gauss to —1.0 gauss, 3% each axis.

Power Requirements: 60 cycles or 400 cycles.

We think that the Dycome System can be the cure for a lot of research-induced ulcers and production-testing pains. So if what you are doing demands that you be able to control magnetic fields, let's talk. Call St. Louis, CEntral 1-5830, or write 1743 Locust Street, St. Louis, Missouri 63103. Ask for Dycome Bulletin 4606-3.

VE93-2

VICKERS

DIVISION OF SPERRY RAND CORPORATION
ELECTRIC PRODUCTS DIVISION

Circle No. 2 on Subscriber Service Card

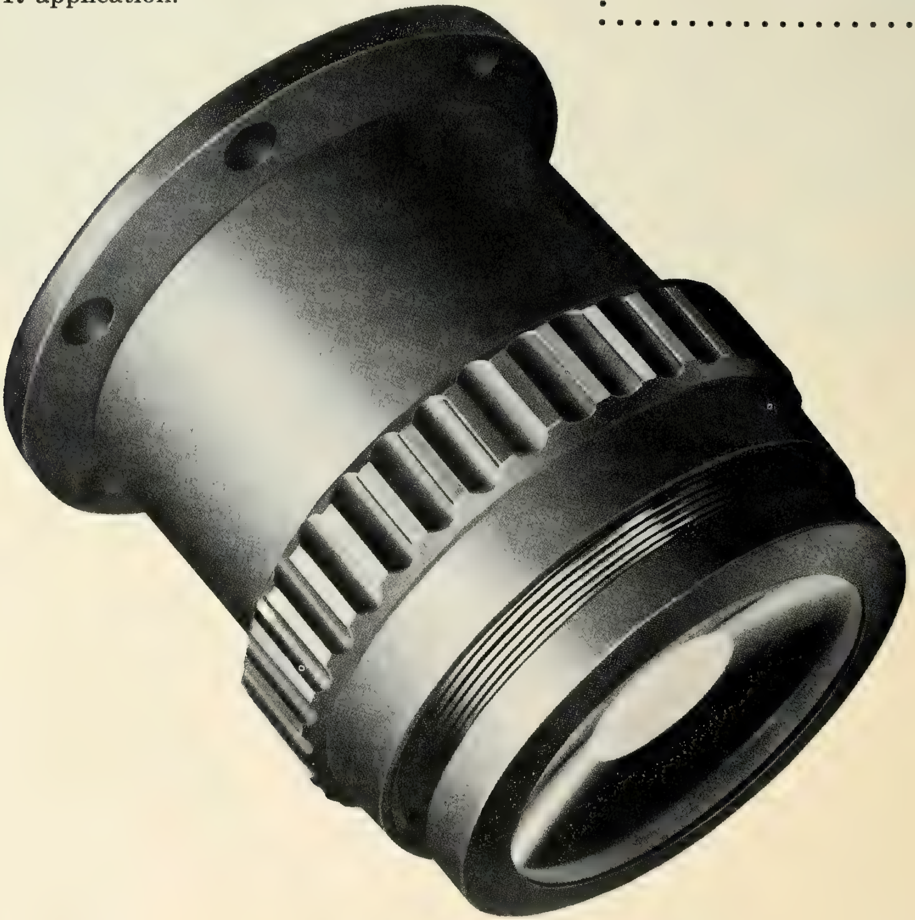
A NEW CATADIOPTRIC LENS

This new computer-designed lens assembly was developed to withstand severe environmental conditions such as those existing in airborne or spaceborne, television tracking and guidance equipment. Its resolution is diffraction limited.

General Electrodynamics Corporation will provide, on short notice and with minimum development cost, focal lengths and effective apertures to fit YOUR application.

Environmental Characteristics:

Vibration:	10g from 10 cps to 2,000 cps
Shock:	100g for 5 ms
Temperature:	—65°F to +250°F without refocusing



For integrated systems employing either optics, sensors or processing electronics, or any combination to meet your requirements, write or call

GENERAL ELECTRODYNAMICS CORPORATION

4430 FOREST LANE • GARLAND, TEXAS • BROADWAY 6-1161

Circle No. 7 on Subscriber Service Card

The Countdown

WASHINGTON

Budget May Escape Heavy Cutting

Prospects for the DOD and NASA budgets on Capitol Hill look better this year than in any recent session of Congress. Feeling is that the FY '66 requests have been trimmed down almost enough—in some cases too much. Attention of the usual critics is directed elsewhere.

Apollo-X Money Switched to Apollo

Sharp drop from $26 million to $10 million for advanced manned mission studies in NASA's FY '66 budget reflects the transfer of the *Apollo-X* funding into the Project *Apollo* budget. The $10 million will be used for studies of uprating the current stable of launch vehicles, manned interplanetary travel and recoverable boosters.

ASW Weapon Buys Climbing

In addition to continued procurement of *Subroc*, the FY '66 budget earmarks $326.25 million for Weapons and Support Equipment for ASW. Included are procurement of Mark 46 torpedoes, mines, *ASROC*, submarine detection devices, and equipment for improving launch and fire control systems.

GT-3 Booster Awaits Its Capsule

The *Gemini/Titan-3* space capsule which will be used in the upcoming three orbital manned space flights will be tested for the next two weeks at the pyrotechnic facility at Cape Kennedy. Erection of the *Titan II* booster on the launch pad was completed last week. Capsule and booster will be mated late this month.

MOL/Apollo-X Cooperation Pressed

Liaison between NASA and DOD on their *Apollo-X* and *MOL* programs is being handled by an Air Force Systems Command group and a special group working under Associate NASA Administrator Dr. Robert C. Seamans. The latter force is headed by Robert Garbarini, director of engineering in the Office of Space Sciences and Applications, assisted by Douglas Lord. It is primarily involved in providing DOD with information on *Apollo-X*, so that it can be compared with the AF's *Gemini/Can MOL* concept.

Cancellations Stir Senate Critics

Booster briefings held by the Senate Space Committee last week gave Congress its first opportunity to air its reaction to cancellation of the M-1 and big-solid booster programs in the NASA budget. Some very influential Senators are extremely concerned and have begun putting on pressure.

Sea-Launched Warning System Developed

Out of the "black funds" there has appeared another apparition: an "austere" sea-launched ballistic missile warning system. It enters procurement in FY '66. Earlier this year, Gen. LeMay, in testimony released by Congress, said that the Air Force proposed such a system. But there has been nary a word about it since.

SRAM Funding Comes to $34 Million

Some questionable arithmetic puts budget funding for the *Short-Range Attack Missile* at $34 million. Total package for component work on the AMSA was estimated at about $70 million by DOD officials. Avionics and propulsion work for the aircraft are expected to cost about $36 million. SRAM is allocated the remainder.

Titan Complex Set for Vandenberg

Indication of the seriousness with which DOD is approaching the MOL decision is the line item in the military construction budget for a *Titan III* complex at Vandenberg AFB, Calif. This will give the Air Force capability of placing in polar orbit the unmanned or manned payloads which can observe the entire surface of the Earth.

INDUSTRY

STL Wins Award for LEM Descent Engine

TRW Space Technology Laboratories has been selected as winner of the competition to develop the variable-thrust lunar descent engine for the *Apollo* Lunar Excursion Module. This was confirmed by a spokesman for Grumman Aircraft Engineering Corp., prime for LEM, who said the program so far conducted by STL has been worth about $25 million to that company, and the balance of the program—completing engine qualification and delivering some 25-30 engines—should add another $25 million. He said the entire development is "about mid-stream" and the powerplant is "a few months away from qualification." STL and Rocketdyne Div. of North American had been in a close competition for the award.

Raytheon Now Taking Over Amana

Raytheon, Inc., reports it is planning to acquire Amana Refrigeration, Inc., of Amana, Iowa, a major commercial refrigeration supplier. It's the electronics firm's fifth acquisition in recent months. Raytheon explains that the action is designed "to build a commercial, industrial products division." An agreement announced last week said the larger firm would acquire Amana for between $10 million and $12 million in Raytheon common stock.

INTERNATIONAL

Vacuum in French Space Thinking?

Some smaller member countries of the European Space Program are concerned that nationalistic trends in space activities by larger members may destroy the cooperative program when its agreed-upon eight-year period is up. They cite France's construction of its own space simulator—useful volume 9 ft. by 9 ft. diameter, vacuum 10^{-}[illegible]mm—as an example of disregard for European unity. Although better vacuum technology was available in Europe, notably in Germany and Britain, France decided to pay the premium for having its own industry develop know-how in this field.

The Missile/Space Week

Gemini Agena Static Fired

Lockheed Missiles & Space Co. has conducted successful static firings of the *Gemini Agena* target vehicle.

The firing tests, which included simulated maneuvers to be made by the *Agena* during rendezvous with the *Gemini*, included five separate firings of the main engine and of the secondary propulsion system. The tests lasted some 12 hours. Lockheed termed the test "complete captive flight."

All systems of the actual flight *Agena* were tested, including command from Earth transmitters, programmed commands within the *Agena*, telemetry and docking simulation. The docking collar was on the vehicle, and ground and spacecraft commands were simulated by electronic equipment.

Previous *Gemini Agena* firings in 1964 were for the purpose of testing the vehicle's engines only.

Comsat Corp. Pact to Hughes

Communications Satellite Corp. plans to award Hughes Aircraft Co. a $100,000 letter contract for work on a comsat system it has made a proposal to run for the Dept. of Defense.

If DOD accepts Comsat's proposal, Hughes could be awarded an additional $14-million fixed-price contract to provide 24 of the satellites, which would be launched in early 1966 by DOD.

The satellites would be modifications of *Early Bird* and would be orbited in three launches of eight satellites each. Booster would be either *Titan III-C* or *Atlas-Agena*.

The letter agreement with Hughes goes from the effective date until Feb. 20 for "work required by that date to meet the launching schedule of DOD."

156-in. Contracts Awarded

Lockheed Propulsion Co. and Thiokol Chemical Co. have been awarded contracts for development and static firing of three large solid propellant motors.

Contrary to earlier reports, Lockheed will develop two of the motors, and Thiokol only one. Previous indications were that the reverse was true.

Award of the fourth large solid motor — Package 16 — contract has been deferred while the Air Staff evaluates contractor proposals. Reportedly, the proposals postulate a 90-in. motor and the Air Force is interested in a 109-in. motor. The fourth package is expected to be awarded as soon as this evaluation is completed, however.

Two of the three 156-in.-dia. motors — Packages 13 and 14 — will be built and fired by Lockheed. The first will be a flight-weight motor with thrust in excess of 3-million lbs., while the second will produce a thrust in the one-million-lb. range. It will also incorporate a submerged nozzle. Both motors will use liquid injection thrust vector control systems.

The Wasatch Div. of Thiokol will build the Package 15 motor. Also of flight weight, it will have a thrust of over 320,000 lbs. and will use a deeply submerged nozzle, which will reduce the overall length of the motor to under 21 ft.

In announcing the contracts, the Air Force said that these motors would be fired in 1965 and would put the Air Force "in a position for accelerated development of a future family of large solid motors to satisfy a variety of booster applications." The funding for these motors was not revealed.

NASA Construction Down

NASA's FY '66 budget request for construction of facilities fell sharply to only $74.7 million, compared to $262.8 million in the current year.

The drop reflects the winding up of most of the major construction projects at the Manned Spacecraft Center, Cape Kennedy Space Center and the Mississippi Test Facility.

A breakdown of the budget request for individual field centers (in thousands of dollars) follows.

John F. Kennedy Space Center: RF systems test facility (1,374); flight crew training building extension (1,425); extension to the medical facility (598); utility installations—new area (3,898); modifications to launch complex No. 17 (1,300).

Manned Spacecraft Center: Modifications to the environmental testing laboratory (3,600); center support facilities (800).

Marshall Space Flight Center: Non-destructive testing laboratory (708); additions to materials laboratory (1,107); test engineering building extension (616); extension to high-pressure gas systems (1,415); LOX storage facilities for west test area (930).

Michoud Plant: Improvements to the storm drainage system (300).

Mississippi Test Facility: Addition to S-II stage checkout & storage facility (1,177); general support facilities (944).

Goddard Space Flight Center: NASA space science data center (2,000); utility installations (400).

Wallops Station: Launch control building (605); assembly shop (443).

Ames Research Center: Systems engineering facility (2,749).

Electronics Research Center: Space guidance laboratory (3,900); optical communications laboratory (2,100); microwave radiation laboratory (3,000); center support facilities (second phase) (1,000).

Langley Research Center: Flight control research facility (3,576); life support technology laboratory (2,492); increased research capabilities of M-6 and 8.5 tunnels (682); magazine and test area for highly reactive chemical mats (1,500).

Lewis Research Center: Building addition to 10 x 10-ft. supersonic wind tunnel for data processing (407); space power research laboratory (460).

Various Locations: Facilities for F-1 engine program (2,007); facilities for J-2 engine program (2,436); facilities for S-II stage program (1,690); deep space antenna facility, Madrid, Spain (472); deep space antenna facility, Canberra, Australia (510); STADAN facility, Fairbanks, Alaska (1,115); Apollo network ground station—Antigua (facility for unified S-band system) (2,700); Apollo network ground station—Antigua (community support facilities) (3,090); Apollo network ground station—Canary Islands (7,674).

All Locations: Facility planning and design (7,500).

START Program Set

START—the Defense Department's *Space Technology and Reentry Test* vehicle—will be based on an ablative re-entry body shape and will focus on the return of instruments and data from orbit.

A "small" re-entry system, *START* will provide "a flexible and accurate system for placing experimental results in the hands of the experimenters where direct examination is necessary," according to the President's annual report to Congress on Aeronautical and Space Activities. Recovery of experimental data from orbit, maneuverability during re-entry and precision recovery are the primary objectives of the *START* program.

Commenting on materials research, the report says that, as a result of the discovery of a method for producing continuously very thin filaments of elemental boron, a very great advance in materials has been made. Measurements of laboratory quantities of these filaments show that they have a tensile strength of 400,000 lbs. per sq. in. and a modulus of elasticity of 60,000,000 lbs. per sq. in.

Work is just beginning on composite materials using three filaments, the report says, "and considerable work must be done to study effects of fiber orientation, percent volume of fiber to resin matrix (plastic), bond integrity between fiber and matrix, environmental effects, cost reduction, process speeds and other production and design problems."

During the coming year, the Defense Dept. plans to carry out three gravity gradient stabilization experiments in addition to the one being conducted for DOD by NASA:

—A magnetically anchored eddy current damper. Satellite configuration will be dumbbell-shaped with a 41-ft. boom.

—A magnetically anchored viscous fluid damper. This satellite will be stabilized around all three axes and will be shaped like a skewed "Y" with three 60-ft. booms.

—An eddy current damper. The satellite will be stabilized about two axes and will also be dumbbell-shaped. An 18-ft. boom will be extended from the satellite with the tip mass being the boom deployment mechanism. In addition, DOD plans a gravity stabilization experiment at synchronous altitude during this time period.

RI Gets Comsat Award

The Army's two communication satellite ground tracking stations at Fort Dix, N.J., and Camp Roberts, Calif., and the Navy's associated shipboard terminal, USNS Kingsport, will be modified for the military satellite communications system by Radiation, Inc., under initial contracts exceeding $5 million.

Work is already under way in the firm's Melbourne, Fla., plant on a $3,835,000 contract to modify the Army terminals. The program consists of a Phase I Design Plan and a Phase II Hardware effort. Work has been authorized so far only on Phase I. The Phase II hardware effort will provide for an option to proceed with either the hardware for the two fixed ground terminals or for the two fixed plus two transportable ground terminals.

The 18-month classified program will be handled by RI for the Army Satellite Communications (SATCOM) Agency, which has responsibility for the Dept. of Defense Communications Satellite Program ground facilities.

Modification to electronic systems aboard the Kingsport will be similar to those required by the ground terminals. The contract, awarded to Radiation, Inc., by the Navy's Bureau of Ships, totals $1.3 million.

The systems modification program, according to Radiation's program manager, Allan Jacobs, "involves conversion of identical SATCOM fixed ground stations (AN/FSC-9) located at Ft. Dix and Camp Roberts and two air-transportable terminals (AN/MSC-44)." The fixed stations employ a 60-ft. solid-skin, honeycomb, paraboloid reflector mounted on a 65-ft. steel tower. Transportable in 11 vehicles, the MSC-44 systems use a 30-ft.-dia. antenna dish.

The Army program will involve replacement of antenna feeds and conversion of receiving and transmitting equipment in each of the four surface installations. Improved receiver sensitivity, frequency agility, and tracking performance are objectives of the modifications.

Chris Butler

John C. (Chris) Butler, Cape Kennedy correspondent for MISSILES AND ROCKETS and *Missile/Space Daily* since 1963, died at the Cape Jan. 25 after a long illness.

A veteran writer and photographer who also was a lieutenant colonel in the Army Reserve, he had earlier free-lanced for M/R, the Voice of America and CBS News, among others. He was a member of the Aviation/Space Writers Assn., the National Press Club, the Canaveral Press Club, and the University Club at the Cape.

A native of Bevier, Mo., Butler is survived by his wife, Susanne, and a daughter.

Interment was to be at Arlington National Cemetery. The family has requested that instead of flowers contributions be made to the Damon Runyon Cancer Fund.

Present antenna reflectors will be retained with minor alterations to the 60-ft. structures of the fixed terminals. Existing apex antenna feeds will be removed and replaced by Radiation-designed Cassegrain horns.

A low-noise, highly stable receiver, employing a cooled parametric amplifier, fully coherent with the transmitter, will be installed in each of the stations. Similarly, the information bandwidth of receiving and transmitting equipment are expected to be increased by a factor of several times by the application of wideband klystrons, diplexers and other components.

New operating frequencies at X-band and power levels of the stations will be in accordance with those approved for space communications at the recent International Frequency Conference at Geneva. Twenty kilowatts of continuous-wave energy will be required by the transmitters.

Shots of the Week

The Air Force on Jan. 21 launched an *Atlas* ICBM from Vandenberg AFB, Calif. In addition to a dummy warhead, the booster carried aloft a piggyback satellite—possibly the *SATAR*—with instrumentation to sample radiation and micrometeorites. The satellite was to be the first ever orbited westward around the Earth.

- Also from Vandenberg on the 21st the Air Force successfully launched a *Minuteman* ICBM. Shot was conducted by a Strategic Air Command crew from Ellsworth AFB, S.D.
- The Navy successfully launched a *Polaris A-3* from the nuclear sub Sam Rayburn on Jan. 23.

Mariner 11.8 Million Miles Out

Mariner IV, launched on Nov. 28, has traveled nearly 105 million miles along its 325-million-mile path to Mars.

At 9 a.m. EST Jan. 28, the spacecraft was to have been 11,873,789 miles from Earth, moving toward Mars at a speed of 12,291 mph relative to the Earth. Velocity relative to the Sun will be 67,086 mph.

Mariner project officials at the Jet Propulsion Laboratory, Pasadena, Calif., reported that all systems are operating normally.

Industry May Receive $23.7 Billion

Figure down from FY 1965 level, although space spending is increased slightly; MOL given go-ahead and could eventually cost $1 billion plus

PRESIDENT JOHNSON has sent to Congress a Fiscal Year 1966 budget which calls for $23.7 billion in new obligational authority (NOA) to be spent with the defense and space industry.

This figure is down $1.7 billion from FY '65 funding for the industry. The $23.7 billion includes the areas shown on the chart below but excludes funding for such items as operations, maintenance and personnel, where the money for the most part is spent in-house.

The heaviest investment in industry comes from the $11.4 billion requested for Dept. of Defense procurement and $6.7 billion asked for DOD research, development, test and evaluation (RDT&E). The overall defense budget sent to the Hill by the President calls for spending of $49 billion.

The Administration has asked for $5.26 billion in NOA for the National Aeronautics and Space Administration, $236 million for space projects at the Atomic Energy Commission, $33 million for Weather Bureau space efforts and $3 million for the National Science Foundation space program.

Overall, Federal space spending rises in FY '66 to $7.114 billion—compared with $6.981 billion in new obligational authority asked for the current fiscal year.

Government spending for all research and development is on the increase, although not growing as fast in percentage terms as the gross national product. The figure for FY '66 is $15.493 billion, as against $15.003 billion in FY '65.

One of the most significant decisions for this industry reflected in the budget is the go-ahead for the Air Force *Manned Orbiting Laboratory* (*MOL*). A top Defense Dept. official suggested spending on the program could eventually go above $1 billion.

NASA's advanced planning, on the other hand, was hard hit by cancellation of the big-solid booster program, the M-1 engine development program and SNAP 8 nuclear powerplant flight-test plans.

Dept. of Defense

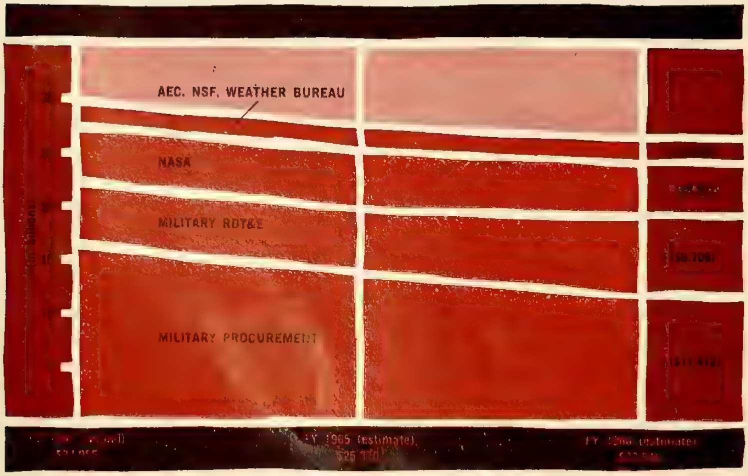
EXPENDITURES for national defense have reached a plateau and are expected to remain at approximately the $49.0-billion level for at least the span of the current five-year programming period. Thus, the defense budget stabilizes at an expenditure level $4.3 billion above that attempted by the FY 1960 and '61 budgets of the Eisenhower Administration.

"Barring a significant change in the threats which face us," the President's Budget message asserts, "it should be possible to maintain the necessary forces, make selective improvements and conduct a vigorous program of research and development without increasing defense outlays each year."

Total Obligational Authority for FY '66 for the Dept. of Defense is expected to be $51.7 billion. It is expected to be $50.9 billion in the current spending year, and was $51.9 billion in FY '64. Direct obligations in FY '66 are expected to be $50.49 billion.

Defense officials admitted that there would be continued upward pressures on the budget, but that these would come from retired pay increases, increases in military compensation and civilian compensation. On the average, these increases are expected to amount to $600 million every year. Since offsetting economies are hard to foresee, Defense officials expect perhaps some increase in absolute budget levels.

Most precipitous drop in FY '66 funding is again in the category of Strategic Retaliatory forces—$800 mil-



FY '66 BUDGET FOR THE INDUSTRY

(in millions of dollars)

Dept. of Defense Procurement	$11,412.000
Dept. of Defense RDT&E	6,709.000
NASA	5,260.000
AEC Space Funds	228.000
Weather Bureau Space Funds	33.100
NSF Space Funds	3.800
TOTAL AVAILABLE	$23,645.900

BUDGET AT A GLANCE

FUNCTION	DOLLARS (in billions)	TREND
Federal Research and Development	$15.49	UP
Federal Space Spending	$ 7.1	UP
Military RDT&E	$ 6.7	UP
Military Procurement	$11.4	DOWN
Military Astronautics	$ 1.6	UP
Military Electronics	$ 0.8	DOWN
Military Missiles	$ 1.4	DOWN
NASA	$ 5.26	UP
AEC Space Funding	$ 0.23	DOWN
Weather Bureau Space Budget	$ 0.03	UP
NSF Space Research	$ 0.003	UP

lion below the current fiscal year—at $4.5 billion. Spending for offensive strike forces has been dropping steadily since the final FY '62 budget, in which they were funded at $9.0 billion. With the exception of Reserve and Guard forces which dropped $100 million from $2.1 billion to $2.0 billion, all other program packages remained the same or increased:

—*Continental Air and Missile Defense Forces:* Remains at the same level as FY '65—$1.8 billion.

—*General Purpose Forces:* Greatest single increase reflected in the $900-million jump from $18.1 billion in FY '65 to $19.0 billion in FY '66.

—*Airlift/Sealift Forces:* Up $100 million—from $1.5 billion in '65 to $1.6 billion in '66.

—*Research and Development:* Up $300 million—from $5.1 billion to $5.4 billion.

—*General Support:* Up $300 million from $14.3 billion to $14.6 billion.

● **Strategic forces adequate**—Pointing out that today the U.S. has on alert 793 ICBM's and has deployed 304 *Polaris* missiles and that these forces are continuing to grow, a Defense official expressed his conviction that these forces are adequate. Adequacy he defined as "having enough power to survive a first strike and survive with sufficient power to absolutely, and I mean literally, destroy the attacker."

To ensure that this strategic force will remain adequate to its task in the future, work is funded in the FY '66 budget not only for *Poseidon,* the Navy's *Polaris* follow-on but also on further development of the *"Minuteman* family" beyond *Minuteman II.* No decision has been made, however, as to whether, once these developments and modifications have been made, missiles incorporating the changes will be procured.

● **Growing emphasis on research**—Although DOD expenditures for development are still the major portion of the RDT&E budget, obligation and expenditures for the conduct of research are on the increase. Development obligations in FY '66 are expected to run at $4,972 million—some $164 million less than the current fiscal-year level—while expenditures for development are expected to decline even more, from $5,355 million in '65 to $4,921 million in '66, a drop of $414 million.

In contrast, obligations for research will rise from $1,860 million in '65 to $2,114 million in '66—an increase of $254 million; expenditures will also go up from $1,757 million to $1,864 million, a jump of $107 million.

Space spending in the Defense Department is increased. New Obligational Authority for DOD space programs amounts to $1,670.2 million in FY '66 as opposed to $1,546.7 million in FY '65. Expenditures for space are projected at $1,610.0 million in '66, a small increase over the estimated spending of $1,570.0 million in '65.

Total Obligational Authority for procurement in the Defense Department drops in the FY '66 budget by $109 million—from $14,026 million in the current budget to $13,917 million in the '66 budget. The decline is even sharper, however, in terms of New Obligational Authority, off from a '65 level of $13,386 million to $11,412 million.

Missile procurement accounted for most of the decrease—dropping in terms of TOA from $2,518 million to $1,806 million. NOA requested was only $1,427 million in '66, contrasted with $2,612 million for '65. Electronics and Communications procurement also sustained heavy cuts; the TOA for '66 is $999 million versus $1,135 million in '65. NOA for this category dropped to $772 million from $1,032 million in the current budget plan.

● **MOL expanded**—The *Manned Orbiting Laboratory* program has been significantly expanded over its original purpose of determining the usefulness of man in space. So different is the concept from that enunciated by Defense Secretary Robert S. McNamara in December, 1963, that Defense officials refer to the program as the "orbital laboratory."

The program now includes manned and unmanned missions in space as well as demonstration and development of manned assembly and service in orbit of large structures (such an antennas), which may have military significance and military applications. Intermediate steps toward operational space systems may also be undertaken in the expanded program.

The *Orbiting Laboratory* program is to be funded in the FY '66 budget at $150 million.

Defense officials also revealed that proposals are being requested from industrial contractors "to assist in developing the cost and technical information required to proceed with the *Manned Orbital Laboratory."*

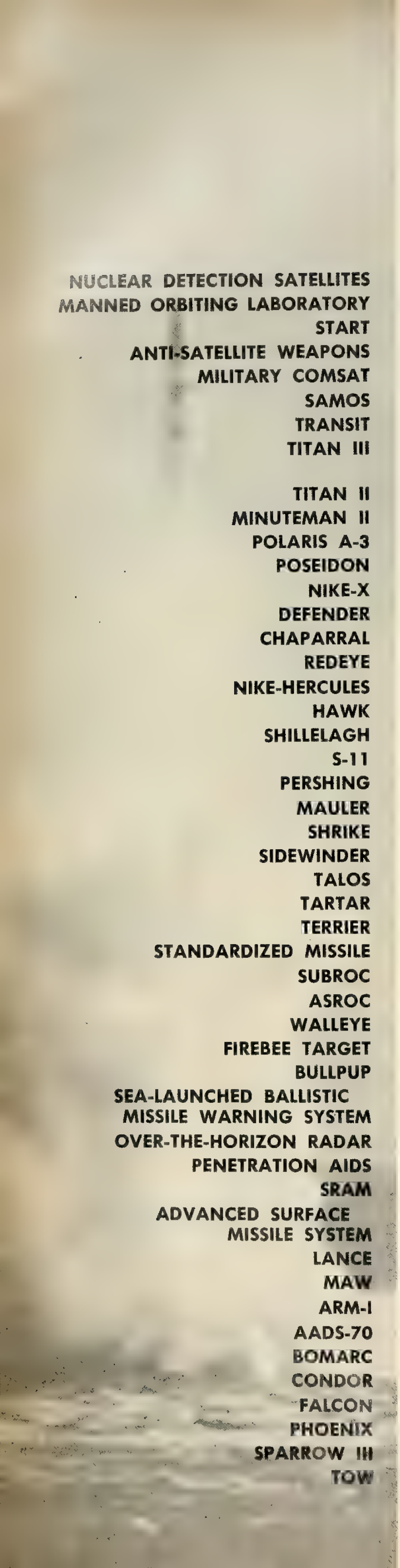
Three contractors, one of which will become the development firm for the program, will be selected for these initial design contracts.

Estimating that the development contract could be awarded by the end of this calendar year, DOD officials defended the new study contracts on the basis that "we are progressing with every month toward development of specific hardware, but there is probably a billion dollars of cost associated with any form of a *Manned Orbital Laboratory* program. . . We are not going to proceed without knowing very clearly what we are buying, why we are buying it and what we expect to gain in the way of military applications."

Although DOD may well buy other launch vehicles, such as the *Saturn IB* for *MOL,* the Department plans initially to use the *Titan III-C* for the program.

Also, in order to preserve the option of manned launches in '68, work will continue on the *Gemini-B* and the *Titan III-C* and "some of the aspects of what might go into any *MOL,"* according to Defense officials. "But the decision to spend the Fiscal '66 money will not be made until those studies are complete. In that sense the full *MOL* program may not be completely decided on and under way until late this year."

(Continued on page 14)

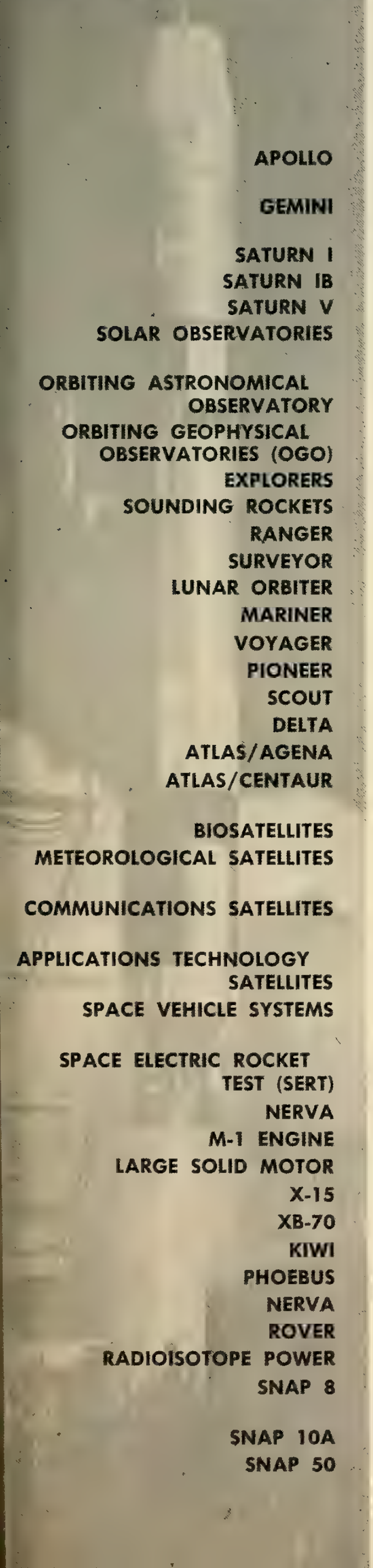


FY '66 BUDGE

DEFENSE

NUCLEAR DETECTION SATELLITES	Experimental work to continue.
MANNED ORBITING LABORATORY	$150 million for development; program objectives expanded.
START	Development on large scale; greater emphasis on re-entry technology.
ANTI-SATELLITE WEAPONS	Funds included for operation and improvement.
MILITARY COMSAT	Development to continue; test payloads to be launched by Titan III-C.
SAMOS	Program continues; greater emphasis on capsule recovery technology.
TRANSIT	Funds included for operation, maintenance and improvement.
TITAN III	Development and flight test program continues; launch facility to be built at Vander berg.
TITAN II	Modification program, result of test results, to be funded.
MINUTEMAN II	Procurement continues as II version replaces Minuteman I; total force, 1,000.
POLARIS A-3	Procurement to continue; $122 million in budget.
POSEIDON	Development of doubled-payload missiles for FBM subs to be initiated.
NIKE-X	Development continues; system tests start; about $400 million in budget.
DEFENDER	Research program continues at $100-million level.
CHAPARRAL	Ground-launched Sidewinder missile to be initially procured.
REDEYE	Army and Marine procurement to continue.
NIKE-HERCULES	Anti-Tactical Ballistic Missile modification program to continue.
HAWK	Anti-Tactical Ballistic Missile modification program to continue.
SHILLELAGH	Procurement continues.
S-11	Procurement for helicopter employment continues.
PERSHING	Continued procurement and improvement modification.
MAULER	Development to continue with prior-year funds; no FY '66 funds.
SHRIKE	Procurement by Navy and AF continues.
SIDEWINDER	Procurement by Navy to continue (see Chaparral).
TALOS	Procurement continues.
TARTAR	Procurement continues.
TERRIER	Procurement continues.
STANDARDIZED MISSILE	Pilot production of new missile to be begun.
SUBROC	Production of sub-launched ASW missile continues.
ASROC	Procurement continues.
WALLEYE	First production buy for Navy and AF of TV-guided bomb requested.
FIREBEE TARGET	Procurement continues on use basis.
BULLPUP	A quantity of non-explosive center sections to be procured.
SEA-LAUNCHED BALLISTIC MISSILE WARNING SYSTEM	Procurement of an "austere" system to be initiated.
OVER-THE-HORIZON RADAR	"First steps toward implementation" to be initiated.
PENETRATION AIDS	Funding in FY '66 to be increased.
SRAM	Development to be initiated on an "if needed" basis; about $34 million in budget.
ADVANCED SURFACE MISSILE SYSTEM	Development to be initiated in this budget.
LANCE	Development to continue; some funds for procurement also included.
MAW	Development to be initiated on one of two competition approaches.
ARM-I	Development to be initiated on advanced Anti-Radiation missile.
AADS-70	Future unclear; PDP may be undertaken during FY '66.
BOMARC	Two squadrons of B's to be retired, leaving six active squadrons.
CONDOR	Development to continue.
FALCON	Development of AIM-47A for YF-12A continues.
PHOENIX	Development is to continue.
SPARROW III	Procurement, including foreign buys, expected.
TOW	Development to continue; long-lead-time items for production to be procured.

PROGRAMS AT A GLANCE



NASA AND OTHER

APOLLO	Spacecraft funding increases from $992.4 million to $1.1 billion. $222.2 million for mission includes $50 million for program definition of Apollo systems.
GEMINI	Funding drops from $308.4 million to $242.1 million, with $122.7 million for the spacecraft and $88.6 million for launch vehicles.
SATURN I	Funding drops sharply—from $55.4 million to $4.4 million.
SATURN IB	Funding relatively level—$274.7 million compared with $261.7 million last year.
SATURN V	Sharp increase from $965 million to $1.236 billion.
SOLAR OBSERVATORIES	Sharp rise from $17.3 million to $37 million reflects go-ahead for the Advanced Orbiting Solar Observatory (AOSO).
ORBITING ASTRONOMICAL OBSERVATORY	Funding remains about the same—$32.5 million compared with $31.2 million last year.
ORBITING GEOPHYSICAL OBSERVATORIES (OGO)	Funding increases from $30.2 million to $31.7 million.
EXPLORERS	Request increases from $21.9 million to $25.7 million.
SOUNDING ROCKETS	Budget request increases slightly—from $16 million to $17 million.
RANGER	Funding drops sharply—from $15.2 million to $1.4 million.
SURVEYOR	Funds increase from $76 million to $85.6 million.
LUNAR ORBITER	Slight decrease—from $42.4 million to $37 million.
MARINER	No further flights planned; funding drops from $21 million to $3.8 million.
VOYAGER	Start of development funding forces a sharp rise—from $7.7 million to $43 million.
PIONEER	Funding drops from $15 million to $8 million.
SCOUT	Procurement decreases from $13.1 million to $11.7 million.
DELTA	Procurement drops from $32.6 million to $30.7 million.
ATLAS/AGENA	Procurement up from $60 million to $82.3 million.
ATLAS/CENTAUR	Procurement up from $47.8 million to $69.8 million; in addition, $59.6 million will be spent on Centaur development.
BIOSATELLITES	Funding remains level at $16 million.
METEOROLOGICAL SATELLITES	Funding up about 33% to $42.7 million, with $4.8 million for TIROS, $22.7 million for Nimbus, and $4 million for flight experiments.
COMMUNICATIONS SATELLITES	Funding drops sharply—from $8 million to only $2.8 million, with $200,000 for Relay, $100,000 for Syncom, and $2.5 million for supporting research.
APPLICATIONS TECHNOLOGY SATELLITES	Budget request up slightly—from $21.6 million to $26.7 million.
SPACE VEHICLE SYSTEMS	Funded at $35 million, including $500,000 for Project Fire, $5 million for Scout re-entry tests, $2.5 million for Pegasus, and $24 million for supporting research.
SPACE ELECTRIC ROCKET TEST (SERT)	Funding level increases slightly—from $2.3 million to $3 million.
NERVA	Funding request up from $34.2 million to $35 million.
M-1 ENGINE	No funding requested.
LARGE SOLID MOTOR	No funding requested.
X-15	NASA funding down from $1.425 million to $900,000.
XB-70	Funding of $10 million for NASA flight research project.
KIWI	No funds because project phases into Phoebus.
PHOEBUS	Up $3.05 million because of drive toward as-yet-unfunded flight test program.
NERVA	Down slightly, to $43.2 million.
ROVER	Gain in Phoebus overbalances loss of Kiwi, to show slight funding gain to $84.1 million.
RADIOISOTOPE POWER	Up $3.5 million, reflecting strontium-90 space generator program and increased R&D.
SNAP 8	AEC money down from $14.475 million to $9.5 million because funding is only through ground test. No NASA funding.
SNAP 10A	AEC $13-million request is only for second flight test, if needed.
SNAP 50	AEC funding is up $2.3 million, reflecting continuing effort plus cost-of-living increase.

(*Continued from page 11*)

NASA

FOR THE FIRST TIME in three years, NASA's FY 1966 budget request of $5.26 billion includes funding for new space projects with a total cost of billions of dollars.

If the budget is approved by Congress, the next fiscal year will also mark the first year the space agency's actual expenditures have topped $5 billion.

The new spending total is expected to be $5.1 billion, compared with $4.9 this year and $4.1 billion in FY '64.

Major new projects to be initiated in FY '66 include Project *Voyager*, budgeted at $43 million, and *Apollo* Extension Systems *(Apollo-X)*, with funding of $50 million.

Other projects which will receive hardware development funding for the first time are the *Advanced Orbiting Solar Observatory (AOSO)*, for which $25.1 million has been requested, and the relatively cheap Radio Astronomy *Explorer* Satellite.

There was some bad news in the new budget, however, for portions of the missile/space industry. Dr. Robert C. Seamans, Jr., Associate NASA Administrator, announced that there would be no funding in FY '66 for three current projects: development of the 260-in.-dia. solid motor, the M-1 liquid hydrogen engine, and the SNAP 8 nuclear electric power unit. Seamans said "overall budget considerations," rather than any lack of faith in their technical feasibility, forced NASA to drop them.

- **Some reassurance**—The agency later clarified its position in a telegram to contractors in the programs—Thiokol Chemical Corp. (260-in. solid rocket) and Aerojet-General Corp. (M-1 engine, 260-in. solid motor and SNAP 8 power conversion unit).

It said that it expects to spend about $10 million in remaining FY '65 funds to conduct some test runs of the M-1 turbo pump and thrust chamber. It said also that hoped-for full-engine firings will have to be canceled. Cut-off point in the program will be August, 1965.

In an obvious plea for Congressional help in restoring the big-solid funding, NASA stated that construction of facilities, and such hardware items as nozzles and motor cases, are well along and that this makes selection of logical cut-off points in the program difficult. It said it will spend whatever remains of the original $15-million FY '65 authorization before shutting down the project.

As for SNAP 8, it said a limited effort would continue until mid-1967. It plans to use funds already committed to the program for a 10,000-hr. endurance test of the 35-kilowatt power conversion system at Aerojet.

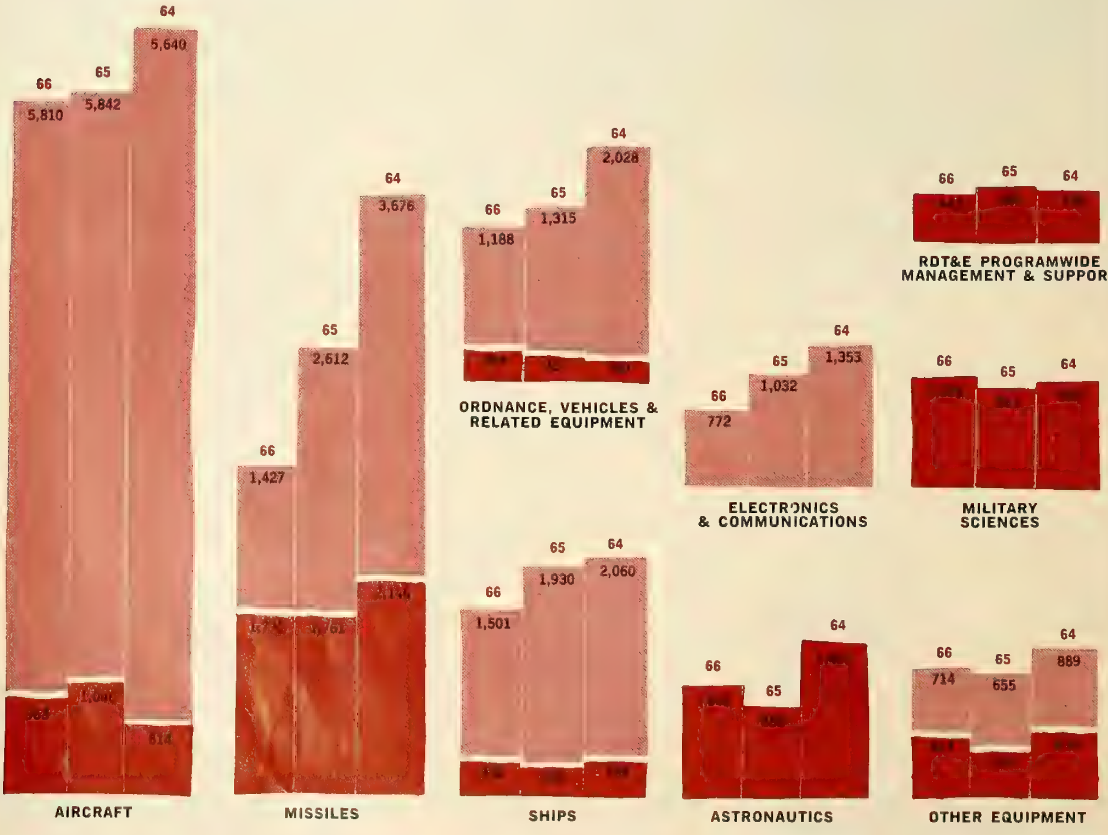
- **R&D stressed**—The agency FY '66 total includes $4,575,900,000 for research and development, $609.4 million for administrative operations and $74.7 million for construction.

It is slightly above the $5.25 billion appropriated by Congress for the current fiscal year, which included $5.177 billion by '65 authorization and $72 million in a FY '64 supplementary appropriation.

The new budget reflects the trend toward channeling more and more of the agency's total funding into its R&D.

The request for its various research and flight projects is $200 million higher than last year's $4.3 billion total. Conversely, construction funding drops sharply from last year's $262.8 million total as the big build-up at Cape Kennedy, the Manned Spacecraft Center and the Mississippi Test Facility ends.

Administrative operations also dropped slightly from last year's level of $623.2 million, primarily because of a



GRAPHS SHOW changes in DOD RDT&E (dark areas) and procurement during three years (figures in millions).

switch in the agency's computer and data-handling activities.

- **Hopeful on Moon date**—Seamans labeled the budget an austere one, but he said the chances of landing a man on the Moon by 1970 were still good. He commented that the three- or four-month slippage in the U.S. *Apollo* schedule—caused by Congressional cuts in the FY '65 budget—pushed some of the *Saturn V* flights into the 1970's.

To be conservative, he continued, the agency feels that it may require all those flights to achieve a manned lunar landing; thus, conceivably, the first landing could slip into the 1970's.

He said, however, that the recent design freeze on the *Apollo* spacecraft, together with late results in the propulsion system tests, leads officials to believe that there is more chance that the landing can be made on an earlier flight.

- **Voyager**—In discussing the new programs, Seamans said that the requested $43 million for *Voyager* will be spent on project definition of the spacecraft bus and landing capsule which will explore Mars in the next decade. He commented that the initial funding of the program—which has an estimated total cost of over $1 billion—will also enable the agency to make a Martian fly-by in 1969 to test the spacecraft and launch vehicle prior to the 1971 and 1973 missions.

Prime contractor for the 3,000-lb. spacecraft bus will be selected late in FY '66. A request for proposals for project definition of the landing capsule is expected later this year. Another $5 million is included in the new budget for the design of the new *Saturn IB/Centaur* launch booster vehicle which will launch *Voyager*.

- **Apollo-X**—How soon the *Apollo* Extension System will move ahead is clouded at the moment by the discussions between NASA and DOD over the Air Force's *Manned Orbiting Laboratory*.

NASA's firm decision to extend the capabilities of *Apollo-X* is reflected, however, in the fact that the $50 million requested for it in the new budget is included in the $220 million asked for overall *Apollo* mission support. If it had been made a separate line item it would have made it much more accessible to Congressional budget cutters.

It appears that if DOD does move ahead with the *Gemini/MOL* concept, NASA will move full steam ahead on *Apollo-X*. If, however, DOD switches to *Apollo-X* for *MOL*, NASA, at least in early stages, may be forced to use the spacecraft only on flights which extend lunar staytime.

The agency has planned a program of Earth-orbit experiments costing up to $600 million; eventually, it is almost

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT PROGRAMS

(In thousands of dollars)

	FY 1964	FY 1965	FY 1966
MANNED SPACE FLIGHT	**$2,713,052**	**$2,941,178**	**$3,249,485**
Gemini	418,900	308,400	242,100
Apollo	2,272,952	2,606,778	2,997,385
Advanced mission studies	21,200	26,000	10,000
SPACE SCIENCE AND APPLICATIONS	**$746,879**	**$731,486**	**$797,515**
Physics and astronomy	148,623	136,814	172,100
Lunar and planetary exploration	205,762	206,150	215,615
Sustaining university program	40,000	46,000	46,000
Launch vehicle development	111,900	96,500	63,600
Launch vehicle procurement	129,986	154,672	194,500
Bioscience	21,479	28,700	31,500
Meteorological satellites	63,177	31,200	42,700
Communication satellites	8,413	8,055	2,800
Applications technology satellites	17,539	23,395	28,700
ADVANCED RESEARCH AND TECHNOLOGY	**$317,201**	**$316,468**	**$277,700**
Basic research	22,653	21,231	22,000
Space vehicle systems	45,714	44,495	35,000
Electronic systems	28,700	25,422	34,400
Human factor systems	13,200	13,320	14,900
Nuclear-electric systems	45,963	42,492	27,000
Nuclear rockets	79,176	56,731	58,000
Chemical propulsion	46,000	63,792	30,000
Solar and chemical power	14,000	13,745	14,200
Aeronautics	21,795	35,240	42,200
TRACKING AND DATA ACQUISITION	**$194,347**	**$274,750**	**$246,200**
TECHNOLOGY UTILIZATION	**$3,500**	**$4,750**	**$5,000**
TOTAL	**$3,974,979**	**$4,268,632**	**$4,575,900**

ATOMIC ENERGY COMMISSION

OPERATING EXPENSES

(In thousands)

	FY 1964 (Actual)	FY 1965 (Estimates)	FY 1966 (Estimates to Congress)
ROCKET PROPULSION REACTORS (PROJECT ROVER)			
Kiwi project	20,072	2,350	—
NERVA technology project	49,700	43,676	43,200
Advanced rocket reactor technology			
Graphite reactors (Phoebus)	6,820	24,950	28,000
Tungsten reactors	2,802	3,100	3,200
Supporting technology	481	670	1,000
Nuclear rocket development station operations	8,380	8,714	8,700
Total rocket propulsion reactors	**88,255**	**83,460**	**84,100**
MISSILE PROPULSION REACTORS (PROJECT PLUTO)	12,781	4,000	—
SATELLITE AND SMALL POWER SOURCES (PROJECT SNAP)			
Radioisotope power units	5,371	7,000	10,500
SNAP 8	10,475	14,475	9,500
SNAP 10A	17,814	25,550	13,000
Advanced space power system (SNAP 50)	25,451	19,700	22,000
All other SNAP	20,173	12,825	15,500
Total satellite and small power sources	**79,284**	**79,500**	**70,500**

ATOMIC ENERGY COMMISSION

FY 1966 (Estimates to Congress)

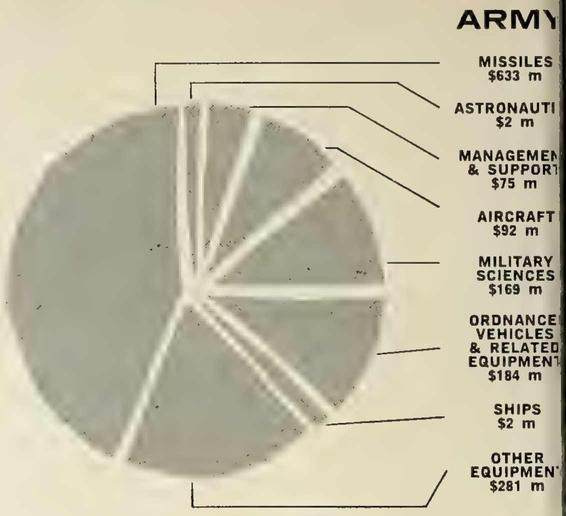
SUMMARY CHART SHOWING MONEY REQUESTS FOR SPACE WORK

(In thousands)

Rocket propulsion reactors (Project Rover)	84,100
Satellite and small power sources (Project SNAP)	70,500
Advanced systems research and development (including a continuation of Pluto technology and $1 million for thermionics)	12,7[illegible]
Nuclear safety	[illegible]
Other activities; space-related activities such as in reactor development, physical research, biology and medicine	[illegible]
Miscellaneous	5,6[illegible]
Operating expenses, total, for AEC space work	[illegible]6,3[illegible]
Space-related construction work	7,3[illegible]
Space-related capital equipment	4,3[illegible]
TOTAL FOR AEC SPACE WORK:	227,900

HOW DOD WILL SPEND ITS RDT&E DOLLAR

Total NOA: $6.709 billion*



* $500 million is to be requested for Defense Agencies; also, $150 million for Emergency Fund

certain to have its own program of *Apollo-X* Earth-orbital flights.

AEC

THE ATOMIC ENERGY COMMISSION will ask Congress for $227.9 million for the agency's space work in FY 1966. This is only a 1.5% drop from the previous year's budget estimate of $231.2 million, but a 3.5% rise over FY '64 expenditures of $220.1 million.

A little more than two-thirds of the FY '66 money is earmarked for development of nuclear rocket propulsion and nuclear power sources for space applications.

The propulsion program, Project *Rover*, is up only $600,000 from FY '65— to $84.1 million. As expected, the program will continue with ground-based development work but not with a RIFT (Reactor in Flight Test) type of program. No money was given to the Kiwi reactor program because that work has phased into the advanced graphite reactor program, Phoebus.

The nuclear power source program SNAP (Systems for Nuclear Auxiliary Power) slipped $9 million from FY '65 estimates to $70.5 million for FY '66. Although more money was given to developing the high-power SNAP 50, there is an overall loss in the SNAP program, accounted for by the decrease in money for SNAP 10A and SNAP 8.

Neither of these decreases stems from a lack of emphasis. SNAP 10A development is just about over. A completely flight-qualified unit went to full power Jan. 22. After a few more tests on non-nuclear components, SNAP 10A will be ready for its first flight test this spring. The $13 million in the FY 1966 budget for SNAP 10A is for a second flight test, if it is needed.

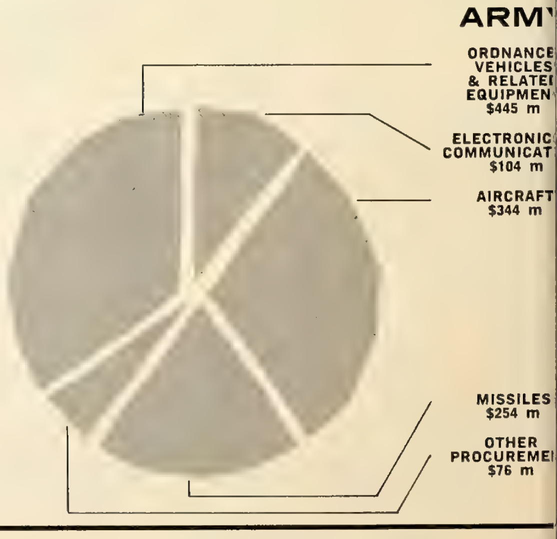
A spokesman for AEC said that flight-testing SNAP 10A will not breach the test-ban treaty.

SNAP 8 fell off about $5 million from FY '65 because the project is funded only through ground test. No money is requested for conversion machinery or flight test, this work presumably being the responsibility of NASA. AEC will be ready to ground-test a SNAP 8 experimental reactor in FY '66, according to John Abbadessa, AEC controller.

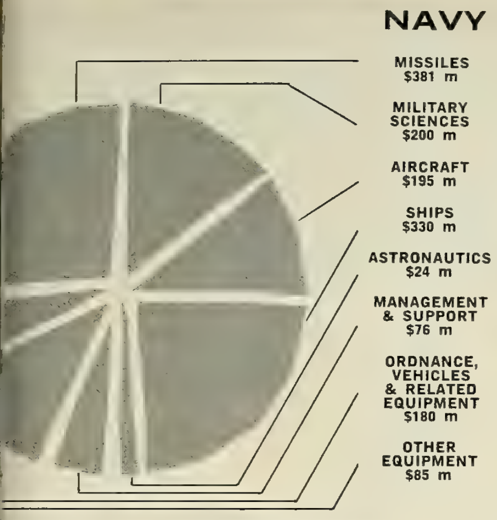
- **Pluto survives**—Although Pluto as a line item was cut out of the AEC budget request, there will be "continu-

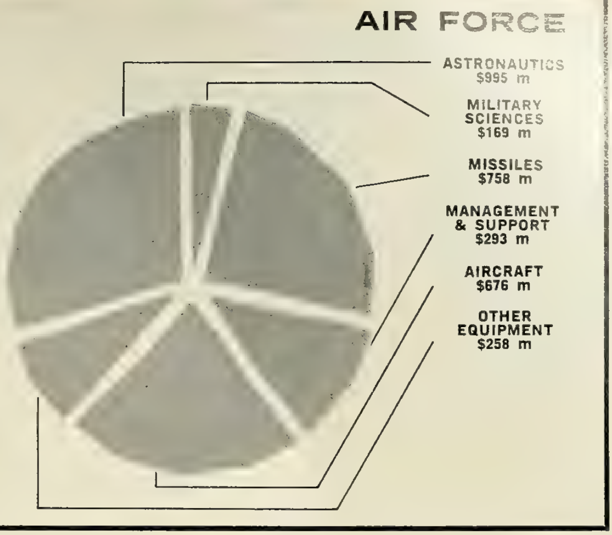
HOW DOD WILL SPEND ITS PROCUREMENT DOLLAR

Total NOA: $11.412 billion*



* Includes $24 million for Defense Agencies





ing work on Pluto technology," said Abbadessa. He explained that the excellent facilities developed during the Pluto work can now be used for studies in magnetohydrodynamics and for work on compact reactors for Earth.

Weather Bureau

THE WEATHER BUREAU is starting its investment in an advanced weather satellite system in the FY 1966 budget with a $500,000 request for sensors and subsystem studies in conjunction with NASA studies.

Funds for three *TIROS Operational System (TOS)* Satellites and four *Delta* launch vehicles are included in the budget request. The funds are for spacecraft to be delivered about two years hence. Total requested is $21.6 million in new obligational authority.

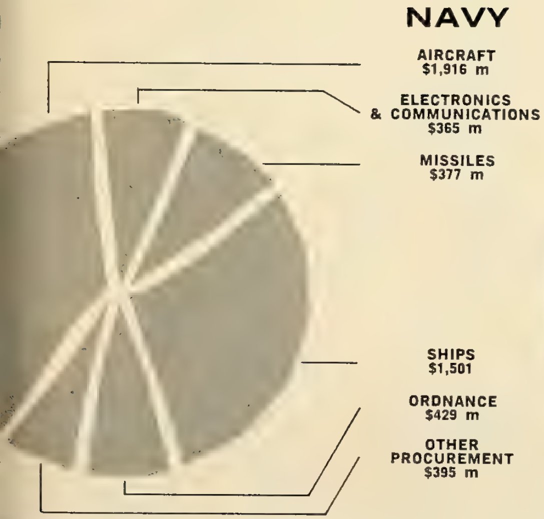
Most of the remainder of the total of $30.1 million requested for the National Weather Satellite Center (NWSC) will go toward conversion of the present *TIROS* command and data acquisition facilities to full-time, operational centers run solely by the Weather Bureau. Funds for the Weather Bureau are included in the Dept. of Commerce budget.

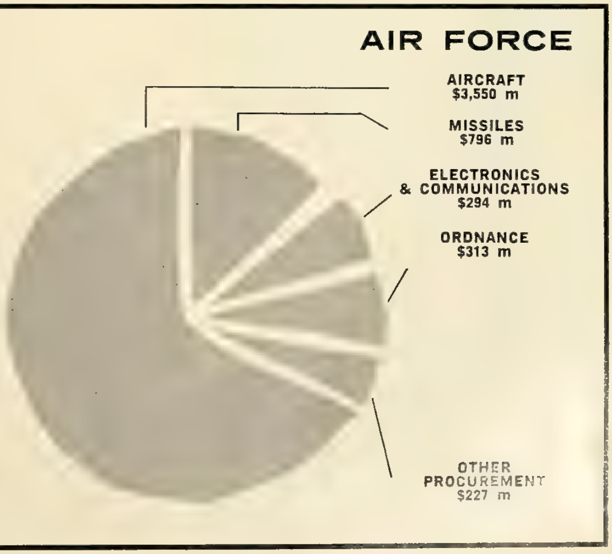
NWSC is seeking $4.209 million for command and data acquisition facilities, for which $5.572 million was received in FY '65 and $4.031 million in FY '64. Although the facilities at Fairbanks, Alaska, and Wallops Island, Va., have been completed, including ground equipment and communication links, the current request is concerned with obtaining the operating staff to run these facilities and gear them to 24-hour operation. An increase in staff of from about 136 to 165 will be necessary.

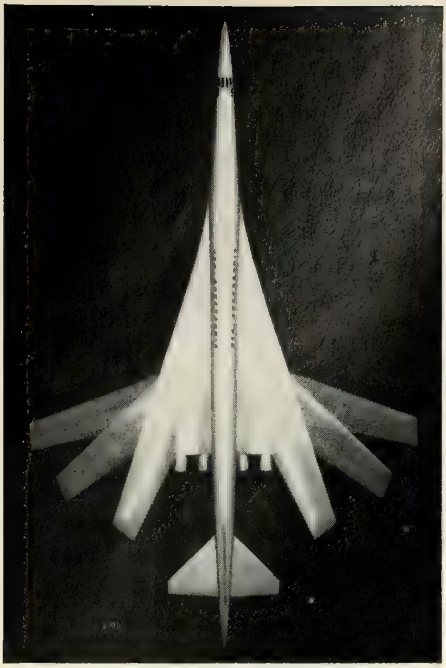
Data processing, analysis and archiving funds have been requested at the level of $3.345 million. These funds, which go to the operation of the computer center at NWSC, were funded at $2.734 million in FY '65 and $2.75 million in FY '64.

Technical management funds are requested at $946,000, compared with $1.157 million in FY '65 and $908,000 in FY '64.

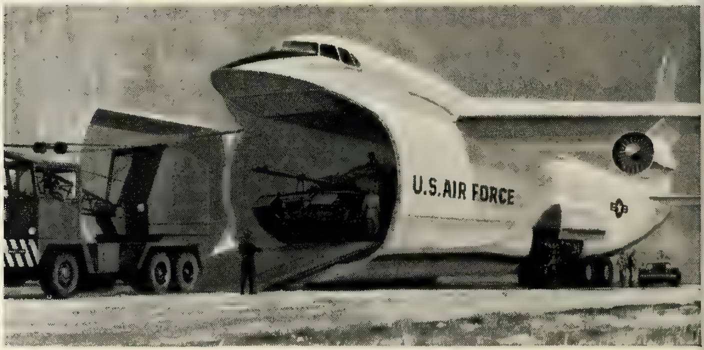
Total FY '65 funds were $34.563 million. However, all but $10 million of this was carried over from previous appropriations. There is no carryover into FY '66.







BOEING 727
BOEING 727



Enjoy a dynamic, long-range career with the world leader in jet transportation

The Boeing Company, today's world leader in the field of jet transportation, is already at work on the next generation of jets — including giant military logistics aircraft, supersonic passenger liners and other manned aircraft systems. Boeing's current business backlog is approximately $2 billion, of which some 60% is in commercial jetliner and helicopter product areas. The remainder is in military programs and government space flight contracts. This gives the company one of the most stable and diversified business bases in the aerospace industry.

Experienced engineers and scientists who look toward expanding the scope of their careers in this dynamic field will find professional challenge and unique advancement opportunities with Boeing's Airplane Division. Immediate openings are available at both Renton (near Seattle), Washington, and Wichita, Kansas, for qualified graduates in engineering, physics, mathematics, business administration, operations research and production management. Specific areas of assignment are listed at the right.

Salaries are competitively commensurate with your experience and educational background. Moving and travel allowances are paid to newly hired personnel. Boeing is an equal opportunity employer.

Send your resume, today, to:

Mr. Thomas Sheppard, *Airplane Division*
The Boeing Company, P.O. Box 707-BAT,
Renton, Washington 98055

or

Mr. Gerald Caywood, *Airplane Division*
The Boeing Company, Dept. BAT,
Wichita, Kansas

BOEING
AIRPLANE DIVISION

Other Divisions: Aero-Space • Turbine • Vertol
Also, Boeing Scientific Research Laboratories

DESIGN ENGINEERING

- Structural
- Hydraulic
- Air Conditioning & Pneumatic Systems
- Aircraft Control
- Power Plant
- Fuel Systems

DEVELOPMENT ENGINEERING

- Structural Dynamics
- Stability & Control
- Flight Control Systems
- Fatigue Analysis
- Loads Analysis
- Stress Analysis
- Hydraulic and Electrical Systems
- Weights
- Environmental Control
- Metallurgy
- Non-Metallic Materials
- Antenna Systems
- Support Equipment/ Facilities (Electronics)
- Propulsion
- Navigation and Guidance Systems
- Radar Technology
- Military Operations Analysis
- Weapons Delivery Systems
- Flight Operations Instrumentation
- Electronic Countermeasures
- Human Factors
- Tool Design
- Costs & Schedules
- Technical Writers

Technical Countdown

ASTRONAUTICS

Martian Atmosphere Tied to Efficient Vehicle

Confirmation of even the least favorable of the predicted Martian atmospheric conditions would allow a significantly increased payload for a soft landing vehicle. Ernest Merz of General Electric's Re-entry Systems Dept. told last week's AIAA Space Sciences Meeting that knowing the best of the predicted ranges of existing conditions on Mars would permit more than tripling the payload-to-vehicle ratio. Merz reported the results of a company study concerned with the effects of a firm definition of the Martian atmosphere on advanced landers. The results were applied to an optimum mission that would use a *Saturn V* launch vehicle. The conclusions were drawn from comparisons made against a universal lander designed to handle any and all of the predicted atmospheric conditions.

Operable Fuel Cell in MOL Mockup

An operating fuel cell, yielding drinking water as well as power, will be installed in a full-scale *MOL* mockup. Included by Lockheed in its effort to interest the Air Force in the firm's *MOL* concept, the fuel cell operates on hydrogen and oxygen and delivers 1.5 kw of direct power at 28v. Developed by the Research Division Laboratory of Allis-Chalmers, Milwaukee, the cell exceeded its design power by 300w during acceptance tests. The Lockheed purchase follows by three months a study financed by the Air Force to examine fuel cell requirements for *MOL*. Allis-Chalmers also holds a $3.1-million NASA contract to explore application of fuel cells in spacecraft advanced power systems.

PROPULSION

LPC Reveals Non-metallic Hybrid Fuel Data

Information gleaned from experiments with non-metallized fuels in hybrid motors using both fluorine and oxygen oxidizing systems at Lockheed Propulsion Co. points to the necessity of regression rate knowledge in the development of such propulsion systems. In studies conducted under Dr. L. D. Smoot, oxidizer flow rates and pressures were varied over wide ranges. In the low-flow-rate region, the regression rate was independent of pressure. It increased with the specific total flow rate as predicted for heat-transfer-controlled combustion with the propellant formulations studied. In addition, the experiments showed that at the higher flow rates, the regression rate was nearly independent of flow but increased markedly with pressure. Increasing the percentage of oxygen resulted in a reduction in the regression rates. The studies included two different fuel compounds in a slab burner, with the oxidizer varied from 100% fluorine to 100% oxygen. Agreement between these exprimental results and the regression rates predicted by theoretical means was good in the low-flow-rate regions where regression rates were independent of pressure.

Beryllium Additives In Surveyor Retros

Propulsion grade beryllium powder will be produced by General Astrometals Corp., subsidiary of Anaconda Co., for use in advanced retro-rocket testing at Atlantic Research Corp. The tests are in connection with the *Surveyor* vehicle. The additive is a new, low-cost beryllium powder designated GAC-3, and it has been fired in tests at ARC's Pine Ridge, Va., facility. *Surveyor* program manager, Jet Propulsion Lab, has asked for feasibility demonstrations of *Surveyor* retromotors incorporating beryllium powder. ARC has been requested to run such tests under a feasibility contract.

SPACE MEDICINE

X-Rays Examine Human Mobility

X-ray photographs are being used to study mobility and comfort problems that might occur in the *Apollo* and *Gemini* spacesuits. The Baylor University School of Medicine also is using films to compare mobility of subjects when they are suited and unsuited. Test subjects are NASA and Army volunteers, and Atomic Energy Commission standards are being used. The subjects perform head nodding, head rotation and shoulder, elbow, wrist, hand and thumb-finger opposition movements. Joint mobility is of particular interest. Information will be immediately fed back to the suit contractors so that modifications, if necessary, can be made.

ELECTRONICS

High-Temperature Batteries Developed

Batteries developed by the Astropower Labs of the Douglas Missile and Space Systems Div. retain power at 250° F and can be recharged by solar energy. The units will allow space vehicles to be operated for as long as two and a half months in high-temperature space environments. Pre-launch sterilization is also possible for prevention of transporting Earth microbes to other planets. The high-temperature stability is achieved through unique inorganic separators placed between silver and zinc electrodes fashioned in new designs to resist swelling or other deformation.

MATERIALS

Simulation Chambers to be Built at CANEL

Environmental simulation chambers capable of maintaining 1×10^{-9} torr vacuums in excess of 10,000 hours will be designed and built at Pratt & Whitney's Connecticut Advanced Nuclear Engineering Lab (CANEL), Middletown, Conn., by the Stokes Advanced Systems Dept. of Pennsalt Chemicals Corp. The $450,000 contract covers the construction of two large vertical chambers, 10 ft. in diameter and 14 ft. high, for testing SNAP-50 components.

Mass Sensor Under Contract

Hughes Aircraft Co.'s Malibu, Calif. research labs will design and build a device to sense the mass of an object at a distance through gravitational field detection. Eventual goal of the program is a sensor that can be carried on lunar orbiters to measure the mass distribution of the Moon and to measure mass of asteroids on deep space probes. The $192,000 NASA contract calls for a research model to measure the mass of a moving object within a room. The sensor will consist of an aluminum cruciform about 5 in. in diameter rotating within a vacuum chamber. When the sensor is rotated within the gravitational field of an object, the pull of the object on the cruciform varies with the change in position caused by the rotation. This sets up vibrational modes in the sensor that can be read out by sensitive piezoelectric strain transducers.

DC Motors Stage Comeback in Space

Brushless motors developed by Goddard and Sperry Farragut offer better efficiency and stronger torque, pose challenge to ac units

by William S. Beller

DIRECT-CURRENT MOTORS are on their way back from the limbo where flaking brushes put them.

Engineers at NASA's Goddard Space Flight Center have simply discarded the brushes, which disintegrate in a rarefied atmosphere. This means that for the first time designers will be able to use dc motors for high-altitude and space work. They will get the advantages of higher efficiencies and better starting torques than ac motors can offer. Inverters will not be needed.

These are the benefits that Philip Studer, engineer in Goddard's Spacecraft Integration and Sounding Rocket Div., related to MISSILES AND ROCKETS when he described a family of brushless dc motors developed by Sperry Farragut Co., Bristol, Tenn., under Goddard direction.

Over the years, there have been many schemes for making brushless dc motors but none had been embodied in a practical motor, said Studer. Sperry Farragut, though, did have a machine that worked. It was too big and heavy for space. Working with Studer and his associate, Edward Devine, Sperry Farragut in nine months developed a practical brushless dc motor for space. This was later improved; today, both a half-watt and a one-watt motor showing 65% efficiency are in operation.

This compares with the usual 50% efficiency for a comparable ac motor.

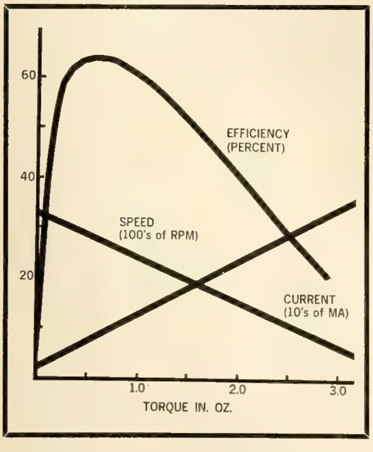
Studer says that a housing of the size used in the one-half and one-watt motors, which can fit easily in the palm of the hand, can be used in a motor rated as high as 15 watts. The half-watt and one-watt brushless dc motors are the latest in the series. The initial design, rated at three watts, was significantly larger.

- **Used in Gemini, LEM**—Although the brushless motor has received very little publicity, except for an early NASA technical note, the merit of the device is becoming widely known. For instance, it was selected to power a static discharge device on the *Gemini* manned spacecraft and to drive an oxygen supply pump for the LEM module. A larger version of the motor will be used to power a cryogenic pump in the *Saturn* launch vehicle.

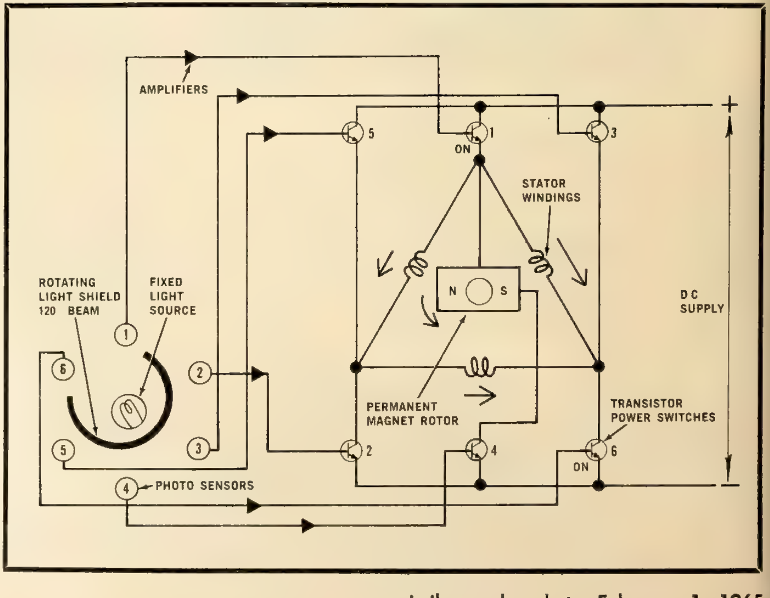
The versatility of the motor was shown last year when its use was extended to a low-speed, direct-drive application. This was incorporated in a brushless dc torquer for reaction-wheel drive. Under development, it is designed to give a high ripple-free torque output with minimum power required over a speed range from 0-250 rpm. A contractor is already building the prototype hardware. Studer reports that calculations and breadboard tests already show that the dc wheel "will have improved torque characteristics and will reduce power requirements by more than a factor of two when compared to an ac-driven wheel of the same mass."

In the broad picture, the sealed brushless dc motor has extensive industrial applications. It could be used in hazardous atmospheres where a spark could cause an explosion: ammunition factories, coal mines, flour mills, and hospital rooms.

Because it eliminates brush wear, and therefore has a long unattended life, the brushless dc motor could be ideal where motors are difficult to reach for maintenance. This obviously includes many space applications as well as ap-



ABOVE: Performance characteristics for one-watt, 24-volt, brushless dc motor.



RIGHT: Functional schematic of the brushless dc motor.

plications in radiation or toxic environments. Then, as a pump motor, the sealed unit could be immersed in the liquid medium.

The motor can also be used simultaneously both as a bearing test instrument and a drive. The dc motor characteristic of linear torque versus armature current allows the actual torque of the bearings to be telemetered back to Earth. Goddard is developing such a bearing-test instrument, which will be packaged in a lightweight housing suitable for space. A test of the package will be run in a chamber within the next six months. Beyond this, Goddard engineers are looking for a space vehicle in which to try out the tester.

Potentially, the bearing problem is serious. The bearing life of even Earth-bound instruments is less than a year. This is under optimum conditions—where bearing fatigue is the problem, not lubrication, as in space. Manned flight will require a high degree of confidence which these bearing tests may help furnish. So far, there has been no corroboration in an actual space vacuum showing what bearings can do for long periods of time.

- **Uses photocells**—Studer suggests considering the dc brushless motor in two parts: the electro-mechanical (torque-producing) element and the photoelectronic (commutating) element.

The torque-producing element consists of a wound stator and a two-pole, permanent-magnet rotor ⅜ in. in diameter by 1-in. in length. The permanent magnet material uses a highly grain-oriented Alnico V, which has an energy product of 7.5 x 10^6 gauss oersteds. The armature is a continuous winding in a 12-slot stator with three terminations.

BRUSHLESS DC MOTOR STATUS

	F.Y. 64	F.Y. 65
INPUT POWER	3.0 WATT	0.5 WATT
EFFICIENCY	53%	65%
SEALING	NOT SEALED	HERMETICALLY SEALED WINDINGS AND ELECTRONICS
RELIABILITY	EST. VALUE 85%	95%, 1 YR
COMMUTATOR SIZE	8 CU. IN.	1.9 CU. IN.
NO. OF COMMUTATOR COMPONENTS	48	24
LAMP POWER (WATT)	0.3	0.03

Studer describes the photo-optical commutator as consisting of a tungsten filament lamp, around which rotates a cylindrical sleeve with a slit. Arranged radially around the rotatable sleeve are six diodes which conduct when illuminated. Power transistors apply the source voltage to the appropriate winding termination when the related photodiode is illuminated. This tends to keep the imposed field perpendicular to that of the permanent magnet and produces near maximum torque at all times.

- **Specifications**—The motors developed later in the program reached efficiencies of 65%. A typical unit develops 0.25 in. oz. of torque at 3,000 rpm with a power input of one watt. A stall torque of 3.25 in. oz. reduces the mechanical time constant to an extremely low value. Predicted reliability for one year of continuous operation is 94.4%. Sealing of the armature windings and electronics prevents outgassing of organic materials from affecting nearby optical or other sensitive equipment.

As a result of these characteristics, Studer recommends that "this type of motor should be considered for space applications where high torque, efficiency and reliability as well as component outgassing are factors in component selection."

The motor is hermetically sealed by enclosing the stator windings within a thin nichrome tube. This seal is said to have negligible effect on motor efficiency and performance. In this design, the only elements exposed to the space environment are the permanent magnet rotor and the support bearings.

The solid-state commutator was simplified over an earlier one by a new motor-winding configuration that reduced the number of transistors and associated circuitry by about one-half, with no compromise in operating characteristics. As a result, the size of the electronic package is reduced to a size comparable to the commutator of a conventional dc motor.

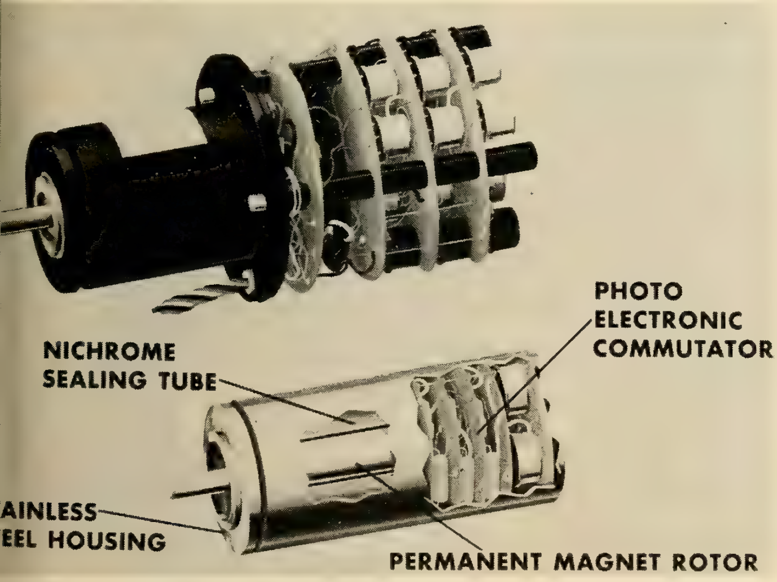
Reliability was improved by reducing the number of active elements and by using highly reliable light sources. Speaking of the light source, which many people assume to be the weakest link in the motor, Studer told of severe vibration tests conducted on the lamps without a failure. These tests involved 70-g random vibration and shock tests up to 2,000g. Moreover, accelerated lamp filament burn-out tests showed that the lamps used in the motors have a probability for a continuous one-year life of better than 0.999.

Looking ahead, Goddard's Spacecraft Integration and Sounding Rocket Division intends to continue its brushless dc torquer work, study precise constant motor-speed control techniques for devices such as tape recorders, look into torque versus speed characteristics and study the applications of pulse-duration-modulated control systems.

Studer does not intend to leave the impression that all ac motors will now be replaced by brushless dc motors. On the contrary, he points out that in the use of ac motors, some capabilities are obtained which are not normally associated with dc machines. The first is the inherent synchronous operation of ac motors; another is the relatively well-developed technology in inverter design. Over the years, this technical work has produced a product of known capability and reliability.

He nevertheless feels that the present development of the dc brushless motor is a major step forward in technology and will help provide more efficient motive power in space. ■

COMPARISON of two brushless dc motors. The larger one, putting out three watts, is housed in eight cubic inches, while the later and smaller motor, rated at ½ watt, could in its 1.9-cu.-in. housing put out as much as 15 watts.

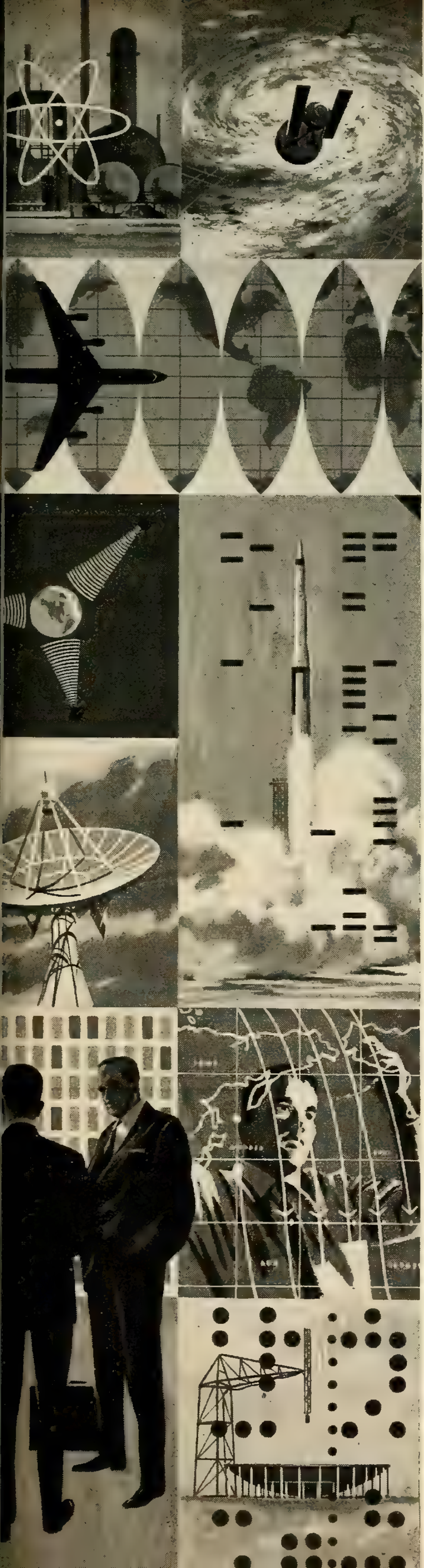


CSC | CSI

SSC

A NEW
COMBINATION OF
INFORMATION
AND COMMUNICATIONS
CAPABILITIES

Computer Sciences Corporation is now one of the world's largest and most experienced information and communications-oriented companies. This new organization, the result of CSC's acquisition of two ITT subsidiaries, Communication Systems, Inc., and Intelcom, Inc., unites the talents of more than 800 specialists in the information sciences. Together, CSC and its two wholly-owned subsidiaries offer an unequaled capability in communications, information, and control systems technologies for industry, science and the military. As part of the CSC family, Communication Systems, Inc. will now operate under the name of Communication Systems Incorporated. Intelcom, Inc. becomes System Sciences Corporation.



Computer Sciences Corporation's senior scientists, mathematical analysts and programmers provide a broad spectrum of responsiveness in computer-oriented problem solutions such as studies in trajectory analysis and orbit determination, command and control systems in space flight operations; design and development of complete integrated programming systems for computers; and preparation of management information reporting systems for industry and the military.

Communication Systems Incorporated's scientists, management specialists and systems engineers are engaged in the design and development of a global communications network for the Air Force, systems analysis and computer simulation of the Defense Communications Systems, and such advanced areas of electronic application as nuclear detection systems, space detection systems, intelligence data handling, and countermeasures techniques.

System Sciences Corporation's scientists and engineers perform engineering and systems management services in the fields of communication satellites, interfacing communication systems, command and control systems, computer logic circuit design, and radar.

For more information about how this unique combination of capabilities can be used to attack multi-disciplinary problems in the computers/communications/management systems spectrum, contact CSC's executive offices or any of the offices listed below.

CSC

COMPUTER SCIENCES
CORPORATION

650 North Sepulveda Blvd., El Segundo, California
San Francisco, Houston, Washington, New York, London

COMMUNICATION SYSTEMS INCORPORATED
South 60, Route 17, Paramus, New Jersey

SYSTEM SCIENCES CORPORATION
5817 Columbia Pike, Falls Church, Virginia

Circle No. 5 on Subscriber Service Card

'Nose' May Sniff Out Systems Problems

Aeronutronic studying flies in effort to develop olfactory transducer for detecting chemical traces in military/space applications

by Russell Hawkes

THIN ELECTRICAL probe is inserted in a sensor-lined pit in the half-millimeter-long olfactory organ on the head of a green bottle fly in experiment to measure the ability of the fly to detect various odors.

A MAN-MADE "NOSE" capable of smelling minute chemical traces is the distant research objective of studies into insect olfactory sensors by Aeronutronic Div. of Philco Corp.

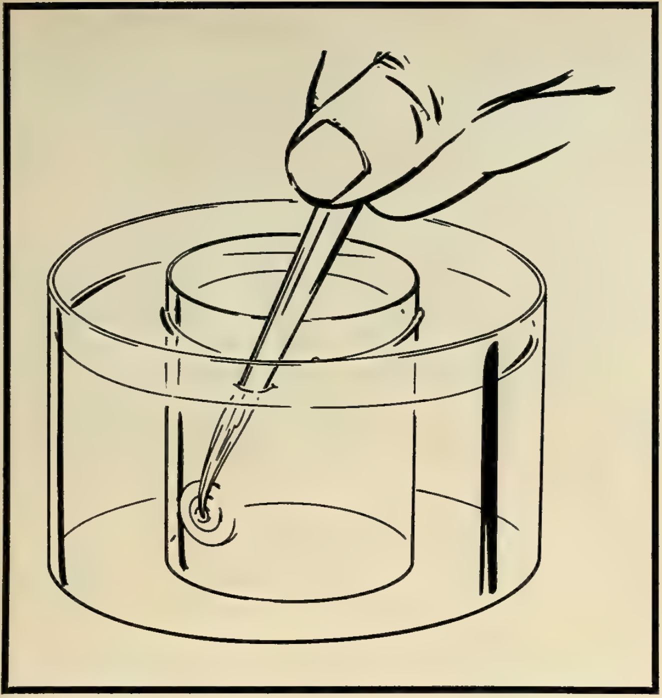
The research has been funded for the past year by a $100,000 contract from the Dept. of Defense Advanced Research Projects Agency. ARPA and the Army's Research Office recently awarded contracts to extend the project for another 18 months.

Among the numerous possible uses for a man-made olfactory transducer are the detection of chemical and biological warfare agents, chemical trails left by submarines or guerrillas, or fluid leaks in spacecraft systems processing plants. Aeronutronic scientists believe that all biosensors have some cell mechanism in common and that if this can be identified and understood, whole new fields of sensor technology will open up.

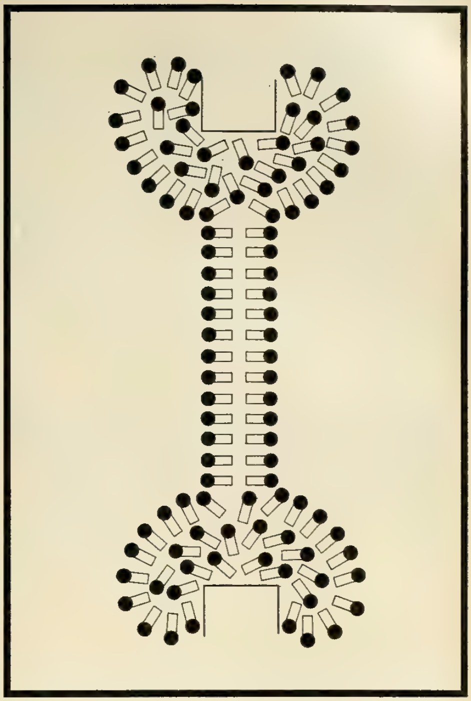
- **Economics of flies**—The selection of the olfactory sensors of green bottle flies as the biosensors in which to seek this mechanism was largely a matter of convenience. The olfactory sense involves none of the unwanted complications of acoustics and optics. Flies are reputed to have a keen sense of smell and they can be obtained cheaply and in quantity. Also, most of the Aeronutronic scientists in the project are biochemists.

The main disadvantage in using flies is the small size of their olfactory organs, which makes them somewhat difficult to instrument. The organs are only a half millimeter long and researchers must insert a capacitance probe with a tip only a half micron in diameter in sensor-lined pits along its length.

The sensing mechanism is related in some way to a change in the ion permeability of the sensor cell wall. This is a membrane of lipids (fats) two molecules deep with a thickness of about 50 Angstroms. There is little variation in the types of lipids of which the membrane is constructed, but on each side of the membrane is a layer of various proteins. Project biophysicists suspect that it is in chemical alterations



LEFT: Two-millimeter-thick membrane is formed over a small orifice immersed in a saline solution. Such man-made membranes will be used to simulate the walls of insect olfactory cells.



RIGHT: Biomolecular lipid membrane before absorption of activating proteins.

to these layers that the sensing mechanism is centered.

In an unstimulated cell the membrane and its protein layers act as a dielectric between relatively high concentrations of potassium ions inside the cell and sodium ions outside—providing about a 70-millivolt potential. When the cell is stimulated, the dielectric breaks down permitting an ion exchange and a minute current flow known as an "action potential." In a sensing cell it is a slow action potential requiring a cycle time of about five seconds from the beginning of the response until the metabolic processes of the cell have returned it to its state of rest. In connective nerve tissue fast action potential is found with a cycle time of 10 or 20 milliseconds.

• **Eight-odor limit**—The main part of the Aeronutronic study is devoted to measuring slow action potential generated in response to various odorants. According to some researchers there are eight categories of odorants, and there are likely to be at least eight types of cells that act as olfactory detectors. It is probable that cells have differing intensity thresholds and respond to overlapping groups of odorants. Thus the cell patterns triggered would classify odors and measure their strength.

A single smell, such as a camphorous odor, can be produced by a number of chemical compounds, and it has been observed that these have similar molecular shapes and chain lengths. The initial electrochemical reaction at the cell wall that begins the sensation of smell may be dependent on these characteristics. This suggests that a man-made analogue may be able to improve on nature by sensing chemicals outside the eight categories of natural odorants.

Though the present work is concentrating upon the performance levels of fly sensors in response to various odorants, proposed follow-on contracts would take a more detailed look at basic cell mechanisms. Aeronutronic scientists have already succeeded in manufacturing lipid membranes two molecules thick to stimulate cell walls. These will be used in experiments to measure electrical properties, but it will be difficult to apply the various protein layers needed to make a realistic model.

Aeronutronic would like to use an electron microscope to study changes in the ATP-ase (Adenosinetriphosphatase) enzyme in sensory cells. ATP-ase is present in all cells. It is generally accepted that ATP-ase is important in neural transmission and it may be active in receptor functions.

Some biochemists have claimed that there are differences in the cellular chemistry of psychotics and normal persons. If so, it is conceivable that enzyme peculiarities in the sensory cells would account for the phenomenon of hypersensitivity sometimes found in psychotics. There is some evidence that hypersensitives may be able to hear the random brownian motion of air molecules. ■

Missile-Control System Flight Tested

THE NEW AN/AWG-10 airborne-radar missile-control system, under development by Westinghouse Electric Corp. for the Navy, successfully met initial performance requirements recently in its first flight test.

Designed as a multi-mission interceptor weapons control system, it is expected to provide greatly improved range and tracking, terrain avoidance, and mapping capabilities for the McDonnell-built F4B jet aircraft.

Being developed for the Bureau of Naval Weapons, the AWG-10 is provided with a self-test capability permitting both system performance evaluation and subassembly fault isolation while in flight.

New Computer Aimed at Tactical Role

Burroughs D84 modular system uses integrated circuits; can operate with several memory and interface units without alteration

by Michael Getler

PAOLI, PA.—A new lightweight and high-speed digital computing system, designed primarily for ground and airborne military applications, is now undergoing pre-production testing at Burroughs Corp.'s Defense and Space Group here.

With the exception of the computer's power module, which is made up of discrete component solid-state circuits, the Burroughs D84 Modular Military Computer is designed throughout with integrated circuits, primarily monolithic silicon devices, but also with thin-film hybrids in certain of the memory modules available.

The extensive use of integrated circuitry in combination with the modular fashion in which the computer elements may be operated enables the D84 to achieve considerable flexibility. For example, Burroughs engineers point out that the computer's Central Data Processor (CDP), which is the system's basic building block and contains the logic for all arithmetic operations and program execution control, has no specialized circuitry and therefore does not have to be disturbed regardless of changes in the system's input/output (I/O) interface control and memory modules.

This, in effect, allows the CDP to be exercised with a number of different memory modules and "custom" interfacing systems without altering the basic data processing functions. The D84 is also designed to allow use of combinations of individual modules such as memory, or CDP's, in order to expand the system and provide both parallel and multiple-processing capability.

Burroughs engineers told MISSILES AND ROCKETS that they have proposed the D84, which has been under development in-house for more than two years, to all three services and "other government agencies" for a range of applications including missile check-out, command and control, and other applications involving navigation and guidance. They also report that first sale of a system for a tactical military application is close at hand.

Burroughs engineers explain that the D84 is aimed at achieving the same flexibility of mission on the tactical level that the firm's D825 computing system (M/R, May 27, 1963, p. 35) has achieved for large system operations, The D825 is being used for real-time air defense data processing with the BUIC program, for a classified Navy intelligence and reconnaissance program, and in a communications switching role for the Army Automatic Missile Processing System.

The basic D84 system, including a 4,096-word, 25-bit non-destructive read-out (NDRO) memory, weighs about 100 lbs, requires 110 watts operating power, and will occupy 1.4 cu. ft., according to Burroughs estimates. These estimates would increase to 3.4 cu. ft., 260 lb, and 150 watts, according to Burroughs, in a D84 system in which four 4,096-word memory modules were used.

Actually, depending upon the type of memory used, the D84 is expandable to a 65,536-word system.

The D84 contains five basic independent modules: the CDP, memory, memory switch module, I/O interface control, and power supply.

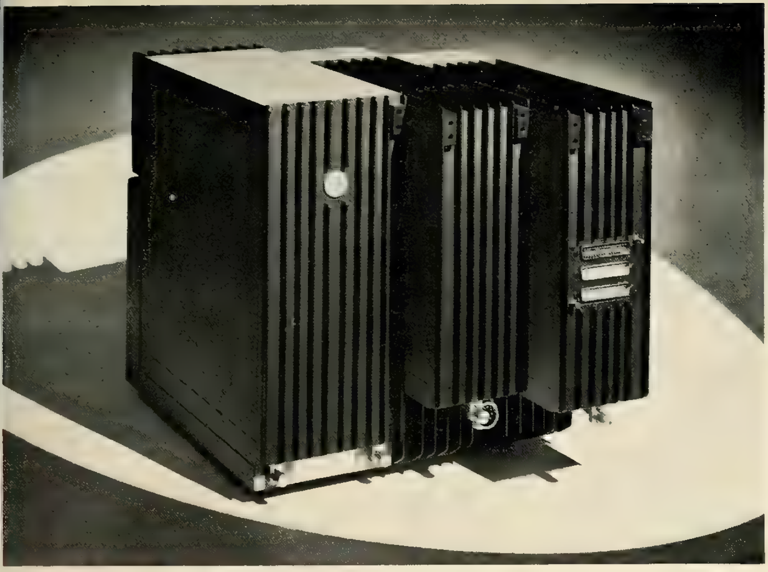
- **Central data processor**—The CDP provides two basic functional areas for D84, the arithmetic unit and the program execution control, and does not require changes when the computer is exercised with different memories or different I/O modules.

It is on the D84 concept of "modularity"—wherein a user in effect will be buying a basic CDP while having the option of using an assortment of memories and also avoiding major redesign costs in achieving a custom interface configuration—that Burroughs is placing major emphasis.

The CDP program execution control includes the memory addressing control, the interrupt logic, and control logic for data transfers between the CDP and the I/O modules.

The CDP logic is implemented with a family of single-input RTL silicon monolithic circuits, a small percentage of which are designed for higher power operation. The RTL devices are actually used throughout the D84, including the CDP, I/O and memory switch modules. Fairchild and GME are supplying these circuits currently; however Burroughs engineers report that other firms, such as Amelco and Signetics, are also qualified suppliers.

- **I/O interface control module**—These microcircuit modules handle all computer inputs and outputs, with the number and type determined by system applications and the peripheral equipment used. There is also provision to directly connect an I/O interface with a memory module, under pro-



LEFT: Prototype D84 shows how memory and interface modules can be interchanged. ABOVE: Circuit network module, used as the basic electronics building block, ripples a printed circuit strip with flat packs attached into accordian-like header assembly.

gram control, to allow an efficient method of resolving conflicts in memory access, according to Burroughs.

- **Memory module**—Three different types of memories are presently available, according to Burroughs: a thin-film destructive read-out (DRO) unit; and two closed-loop ferrite core memories, one which operates in an NDRO mode and the other in a DRO mode. Also under development, and expected to be ready in August, is a new thin-film hybrid system that uses RF read techniques and operates in the NDRO mode.

The D84 is designed to operate with any one of these memories, or with multiple memories of the same type, or with a mix of memory types in the same system.

- **Memory switch module**—This unit is required for systems operating with more than one CDP and is basically a logic unit that provides automatically controlled high-speed channels for the transfer of addresses and data between memory modules and the CDP's. In order to allow concurrent computation, the memory switch module is capable of handling several of these transfers simultaneously, according to the firm.

- **Power supply**—Burrough's engineers report that design of this portion of the D84, which forms part of the base of the actual hardware package, requires only one regulator and one converter per system, does not require an input transformer, and eliminates all electromechanical components with the exception of a power on-off circuit breaker switch.

The microcircuitry used throughout the D84 is implemented into small functional block assemblies, or circuit network modules.

The Burroughs design employs a flexible strip containing a printed circuit for connections, onto which 10 to 12 integrated circuit flat packs are attached by parallel gap welding to the printed circuit strip. The strip is then rippled, accordian style, into a header asembly, dip soldered, and then either encapsulated or conformally coated. The assemblies are then mounted in rows on printed circuit boards, 24 modules to a board. The rows of modules are interleaved, so that they form a thickness equal to a single module when two printed circuit boards are sandwiched together. Each complete set is about 10 x 10½ in. and less than 1 in. wide.

While the D84 operates in its current configuration at a clock rate of 1 mc, the system oscillator is actually designed to operate at faster clock rates, about 4 mc. The constraint, say engineers here, is in the stage delay times, now on the order of 25 to 35 nanosecs. System designers are hopeful that integrated circuit manufacturers will be able to increase circuit speeds to exhibit delay times on the order of 5-8 nanosecs for the RTL devices by the end of the year to further increase D84 speed. ■

SUMMARY OF COMPUTER CHARACTERISTICS

TYPE:	Digital, stored program, synchronous, parallel, fractional binary, fixed point
WORD LENGTH:	24 bits plus parity check bit
MEMORY:	25 bits per word Expandable to 65,536 words
Read cycle:	1 μsec
Store time:	determined by type of memory
ARITHMETIC REGISTERS:	Sign plus 23 bits magnitude
OPERATING SPEEDS:	Basic clock rate 1 mc Basic instruction, including memory access time: 4 μsec
Short instruction:	3 μsec
Add instruction:	4 μsec
Multiply:	25 μsec
ADDRESSING:	Basic: single address, direct On program command: multilevel, indirect
INDEXING:	Index registers stored in memory Number of index registers and their locations program-determined Address field of any instruction modifiable by index register
COMMAND REPERTOIRE:	35 basic commands; more than 150 useful command variations Commands include arithmetic and logical operations, memory search, and block transfers
INPUT/OUTPUT:	Modular Complete I/O flexibility Various interrupts

WSMR Consolidating Control Center

Computer, to be operational in 1967, will afford closed-loop missile flight control, central data-processing capability

by Rex Pay

WHITE SANDS MISSILE RANGE, N.M. —A modular third-generation computer that will give closed-loop control of overland missile flights and provide data processing for all range activities is scheduled to be in operation here in July, 1967.

It will replace the 18 computer main frames currently on the range, providing increased computing capacity at reduced cost.

The new machine will be installed in the projected White Sands Consolidated Computer and Control Center. Plans recently approved for the center show a 46,000-sq.-ft., three-floor building, with the main data-processing areas occupying 10,500 sq. ft.

Requests for bids on the building's construction are likely to come out in the late spring, together with specifications for the computer. Detailed engineering studies of computer requirements have been under way for the past six months.

The Consolidated Computer and Control Center will be "the hub of operations at White Sands," says the chief of the Range Instrumentation Systems Office, Vernon Miller. It will hold a key position in the White Sands ARTRAC (Advanced Range Testing, Reporting, and Control) program. This multimillion-dollar, four-year project will enable White Sands to meet the stringent requirements of new and complex test programs expected by the end of the decade. At the same time it will boost the efficiency of all range operations.

- **Bigger yet**—Operated by the Army for the Dept. of Defense, WSMR currently supports about 3,000 missile firings a year. In this time some 600 instruments collect data on 15-20 million feet of magnetic tape and more than 12 million feet of photographic film.

Greater data processing capacity is expected to become a necessity because of increases in variety and complexity of missile tests, increases in the number and length of missile flights from off-range sites, and increased control exercised by White Sands.

ARTRAC represents a design goal drawn up in a five-year study of future requirements such as these.

The program calls for setting up six Area Data Centers on the Range, each receiving telemetry and tracking data from a variety of local radiation sensors. The ADC's relay data to one Data Processing Center, which is the source of information, for four Operations Control Centers. The main OCC, one ADC, and the DPC will be in the Consolidated Computer and Control Center at the Main Post. Three other OCC's will be at ADC sites on the Small Missile Range, Holloman AFB, N.M., and the Stallion site (in the northern half of the 100-mile range).

The other ADC's will be located at Rhodes Canyon and Oscura Range Camp.

Certain components of ARTRAC have been under development for two years. Implementation of the overall data system will begin this year. Installation of the system outside the CCCC might be handled by a single contractor, but no decision has been reached yet. Hardware or funding limitations may limit the realization of some aspects of the plan.

Within the CCCC, control operations will take up 9,000 sq. ft.—more than half of the top floor. Located on the same floor, the Telemetry Data Center will take up 4,000 sq. ft. The Data Processing Center and the Area Data Center will be on the first floor, and together account for 10,500 sq. ft. The required operational date can be stated to the month because a PERT schedule has been laid out for the entire equipment design program.

- **Many-jobbed computer**—Miller foresees that the single new computer in the DPC will not only replace all present computers on the Range but also increase computation capacity many times. The 18 main-frames currently on the range include an IBM 7094, two 7044's, three 1620's, and seven 1401's.

Computer programs, memory space, control and display equipment will be needed in the Data Processing Center and the OCC's to support up to ten concurrent tests. A single OCC will be able to support several concurrent tests.

"The real key to the computer is that it will be a multi-programmed multi-processing machine," said Miller, "with on-line and off-line jobs being processed simultaneously. The machine will be equipped with an executive routine that gives it the capability to draw on storage and computing modules as required. It will have the flexibility to dynamically allocate more or less capacity to the most critical jobs, as the demand arises."

Remote consoles around the range will also be able to communicate with the computer. In this way, its services will be made available to laboratories and offices.

- **Console puzzler**—One of the most difficult design problems is finding the most effective way for range controllers to use the computer. As yet, the control center has not been designed to the extent of specifying all details of the control consoles.

"My personal idea is that each console will give access to all that information that its controller can use. In general, I hope this is going to be something of a new concept in assimilation of information for control purposes," Miller said.

There may be as many as 20 consoles in the main control center, and controllers probably will be able to call up any information they desire. Some consoles may be equipped with small plotting boards. Alternatively, they might have access to one central plot board by means of closed-circuit television.

However, Miller foresees problems if television monitors are used, particularly with respect to the need for high linearity when zooming in onto range maps. Large group displays, mounted on the control center walls, probably will not be required.

Currently, investigation of console requirements is pressing on rapidly, with design now 85% complete.

One complication is that the missile controller's task is getting more intricate all the time. At present the *Athena* missile, fired into White Sands from Utah, has an onboard program for attitude control. WSMR checks that this has been carried out correctly before firing the final stage at the target area. Miller expects a trend toward putting more control equipment on the ground, with removal of onboard programming. The Control Center will in fact become part of the missile control loop.

To avoid undue lags in this loop, the aim in ARTRAC is to reduce tracking and telemetry data delay to a maximum of 20 millisec. between the occurrence of an event at the vehicle and the emergence of an output at the computer.

Certain types of decision-making will be automated in the CCCC, when human response time is not fast enough. This will be required mainly for range safety in high-boost missile firings of the *HIBEX* and *Sprint* type.

- **By degrees**—In the detailed schedule that has been laid out for implementing ARTRAC, a step-by-step improvement in range capability is planned. Each ADC will be equipped in stages to the same level as the others. For example, all radar systems might be tied in to the ADC's as a first step, to give a complete real-time radar data system. Then the telemetry systems might be tied in as a group, and other systems would follow.

At present, White Sands can handle telemetry in real time at the rate of 50,000 bits/sec. Ultimately the ARTRAC telemetry system may carry a total throughout of 4 million bits/sec.

The design of the telemetry facility for the CCCC is complete and the hardware procurement stage is getting under way. The aim is to be able to bring up to 10 rf carriers into the center. Two would be PCM telemetry, carrying 800,000 bits/sec. each. Four would be FM/FM carriers (4,000 c/s of information per carrier) with up to 18 subcarriers each. The remainder would be additional time multiplex PAM or PDM telemetry.

On the average there will not be this volume of information entering the terminal, but this amount could be accommodated; that needed for real-time decisions is processed directly by the computer, and the remainder is recorded.

- **Built-in redundancy**—The bulk of the telemetry information will be edited to remove redundancy before it enters the computer. This will take the form of limit editing or zero order prediction. In the latter type of redundancy removal, a change in telemetered value will not be passed to the computer until the variation exceeds the system resolution.

The main computer will have separate arithmetic and control functions, to give it the required computing capacity, flexibility, and expandability. A separate computer control module will interconnect compute, storage, input and output modules. Each module will be capable of individual expansion to meet systems needs. The CCCC itself is capable of 100% expansion.

Miller explained that a computer of this type did not require a redundant duplicate on stand-by during real-time operations. "In a modular system a computer does not go out," he said. An individual module may fail but a properly designed program will ensure that when such a condition is sensed the failed module's load will be switched to an identical module. "With proper design you will have redundancy within this one computer," said Miller.

- **Three programs**—There will be three main computer programs. A master control program will coordinate the work of the entire computer complex, carrying out tasks according to established priorities. Executive activity programs will control each operational activity. Operating programs will perform specific computing tasks for the master control and executive programs.

In some operations, several input, storage, compute and output modules may work independently on a particular problem. Even so, operation of the entire computer will remain under direct supervision of the master control module. All data will enter the system through the master control program, except for test data, which are called in at the operating program level.

The master control program will identify input data and select master control routines and executive programs to carry out the required computing tasks. Master control will also allocate computer space and stores, retrieve information, and monitor all computer operations.

A test-progress table will carry all scheduled operations, each being assigned a time of day. Upon receipt of a schedule, a priority change, a hold or other information affecting the time for an activity, the master control program will formulate or update the test progress table. A computer routine will monitor the table with reference to a clock and interrupt the master control program to initiate scheduled operations.

All lower-priority data that enter the master control program will be added to the list of unscheduled tasks in the test-progress table. A routine in the master control program will monitor utilization of computer space and initiate unscheduled tasks as computing space becomes available. Typical inputs for unscheduled operations are schedules themselves, schedule changes, new

jpl
needs SENIOR COMMUNICATIONS SYSTEMS ENGINEERS

MS or BS in electrical engineering or related field. Responsible as systems engineer in the design of spacecraft-ground system communications systems using advanced communications techniques. Requires experience in RF and/or microwave communications equipment development and communication system design project engineering.

Send complete resume to or visit:

JET PROPULSION LABORATORY
4808 Oak Grove Drive
Pasadena, California
Attention: Personnel Department 2

"An equal opportunity employer." Jet Propulsion Laboratory is operated by the California Institute of Technology for the National Aeronautics and Space Administration.

or revised computer programs, and test requirement information.

Executive programs will initiate and monitor assigned tasks, using operating programs and information tables. Each table and operating program may be called in by several executive programs.

Inputs to the computer programs for maintaining the information tables will be entered from many different places, either manually or directly through sensors. At instrument sites operators will provide control inputs; instrument measurements will enter automatically.

At Area Data Centers, operators will insert control and timing inputs, as well as calibration, test and stored data. At the Data Processing Center, operators will provide control inputs and large volumes of data such as schedule information, test requirements, data for post-test reduction, calibration data, geodetic surveys, computer programs, and instrument operating characteristics.

Operations Control Centers will provide inputs concerning missilery, range safety targetry, and range operations—such as test commands, range status, daily schedule changes, priorities, and display data requests.

- **Plan in action**—Operational activities on the range break down into the broad phases of mission analysis, system checkout, pre-flight, flight, and post-flight. All will be supported by the Data Processing Center.

First step in preparing for a test will be to set out a measurement plan that describes the instrument sites and range support resources needed. The plan will then be computed in detail on the basis of user requirements and the requirements for safety, targetry, and range operations. Redundant instruments and resources are added in this computation on the basis of statistical analysis of system failure records. Measurement and performance capabilities of all instruments will be stored in computer memory for use in this phase of its work.

The measurement plan, weather data, and range policy decisions will then be used to lay out weekly and daily range schedules and 30-60 day forecasts. This automatic technique will be capable of rescheduling tests in the daily schedule as well. The program also carries out scheduling of post-test data reduction, preventive maintenance, station manning, and roadblocks.

Checkout of range resources, calibration of instruments, and correction of system faults will be accomplished under computer control. When system discrepancies are discovered, an automatic fault analysis program will search for the faulty elements. ■

LABORATORY
MANAGEMENT

LEADING WESTERN AEROSPACE CORPORATION OFFERS KEY POSITION TO OUTSTANDING SENIOR CANDIDATE TO MANAGE PRIMARY AND SECONDARY STANDARDS LABORATORIES.

Proven laboratory management record with 5 to 7 years experience in primary and secondary standards activity. Must possess knowledge of Bureau of Standards capability, the latest techniques of scientific metrology with a strong desire for acquiring new information and development of new approaches. Must have experience in electrical, electronic and mechanical equipment. Successful candidate will also have a Degree in Science (Physics). Will plan and direct lab activities in wide range of extreme environmental conditions. Will be responsible for personnel and budget control.

OUTSTANDING FAMILY LIVING CONDITIONS, EXCELLENT SALARY, BENEFITS AND MODERN EXISTING FACILITIES.

An Equal Opportunity Employer

Reply in confidence with resume and salary requirements to—

Box No. 105, Missiles and Rockets Magazine, 1001 Vermont Avenue, N.W., Washington, D. C. 20005

DC Amplifier

A dc amplifier specifically designed to drive galvanometers and fulfill general wideband dc amplifier applications has been developed by Astrodata, Inc.

The single-ended Model 141-102 has its own floating power supply and can handle up to 300v of common mode voltage. A front panel concentric control provides selected fixed gains of 1, 2, 5 and 10 continuous adjustment between steps allowing gains up to 25. The device delivers a full ±100 ma at ±10v. Frequency response is within 3 db at 500 kc. Output impedance is normally less than 1 ohm.

Circle No. 151 on Subscriber Service Card

Balanced Mixer

A series of miniature UHF broadband balanced mixers is available from Anzac Electronics, Inc. Four models cover the frequency ranges of 65 to 155 mc; 150 to 270 mc; 260 to 465 mc and 450 to 850 mc.

L.O. power requirement is 0.5 mw. Typical noise figures are 7 db and typical VSWR on all ports is 1.5. The units meet MIL-E-5400 and MIL-I-6181 specifications and have an IF frequency of 60 mc.

Circle No. 152 on Subscriber Service Card

TV Beam Control

A television camera control system that increases the brightness range that cameras can accommodate in a given scene by three orders of magnitude has been developed by General Electric Co.

Possible application for the system is in future explorations of the Moon's surface. TV cameras equipped with the control might eventually be able to distinguish detail in the dark shadows of craters or span the line of demarcation between the light and dark sides of the Moon, developers said.

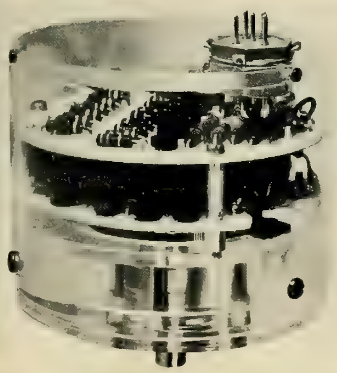
According to the company, the system eliminates the effect known as "blooming," thereby increasing the working latitude of the camera chain.

Results are achieved through dynamic control of the readout beam current in the camera pickup tube. No change in construction of the tube is required. Latitudes as high as 40,000 are reported to TV camera chains equipped with the control, GE said. Latitude of a conventional chain is of the order of 40.

Circle No. 153 on Subscriber Service Card

Incremental Encoder

A magnetic incremental encoder, the Incrosyn, Model IC 25, has been developed by Data Technology, Inc., for use in readout systems or as digital tachometers.



The device may be produced with resolutions up to 4,096 pulses in a single turn with an accuracy of ±0.5 bit. Bi-directional operation may be provided for by the generation of both CW and CCW pulses. Integral 80 to 100 kc interrogation carrier accommodates input speeds from 0 to over 20 kc with no variation in output amplitude (and optionally to over 50 kc). Either positive or negative 10-v pulses may be specified as well as a zero reference of one or more points with a separate output line.

Circle No. 154 on Subscriber Service Card

Isolation Transformer

Scintillonics, Inc., has developed an insulated isolation transformer that is conservatively rated at 1 kva.

The Model HI 7610 is wound on a grain-oriented, silicon iron 12 mil. C core with a power handling capability of 140% of rated power. Minimum copper loss is achieved by winding on both sides of the core. The unit has an insulation voltage rating of 10 kv dc between windings and between windings and the core. Input is 117v, 60 cps; output is 117v with taps at ±10%.

Circle No. 155 on Subscriber Service Card

Message Display

Cal-Glo Co. is marketing a readout that will display up to 48 two-line messages at random from a single film reticle.

The device measures 0.75 x 1.25 x 3.25 in. and is said to be especially adaptable for airborne equipment or where panel space is limited. Viewing screen measures 0.75 x 0.75 in. and features one-plane presentation which may be read from any angle.

Circle No. 156 on Subscriber Service Card

New Product of the Week: Portable Oscilloscope

TYPE 422 OSCILLOSCOPE

A high-performance portable oscilloscope, designed to meet requirements of the engineer in the field, is available from Tektronix, Inc. The Model 422 weighs approximately 20 lbs., and measures 6.75 x 8.5 x 16 in. It can be used for such work as testing and servicing high-speed computers, telemetering equipment and other instrumentation where space for test equipment is limited, the firm says.

The device has a bandwidth of dc to 15 mc and sensitivity to 10 mv/div. It provides dual-trace operation and with a dc power-supply option operates 4 hrs. or more on self-contained rechargeable batteries. It also can operate from any common ac or dc source. A 4-in. rectangular CRT with illuminated internal graticule provides 8.2 sq. in. of display area. Four operating modes include each channel singly, alternate or chopped electronic switching between channels or both channels added algebraically.

Other features include a sweep range from 0.5 μsec./div. to 0.5 sec./div. and a 10X sweep magnifier.

Circle No. 157 on Subscriber Service Card

MISSION ANALYSTS
What will You be doing in 1969?

If you act now, you could be working with TRW Space Technology Laboratories in its new Manned Spaceflight Department at Houston and be a vital part of the Apollo Program. As you know, the Apollo lunar probe is scheduled for 1969.

TRW Space Technology Laboratories is now staffing its new Houston facility. STL has responsibility to NASA for Apollo mission planning, mission analysis and real-time program development. Consequently, STL has ground-floor opportunities in Houston that may never be available again. STL needs employees with experience and training in these areas:

Mission Analysis
Strong analytical ability and technical originality with broad background in flight mechanics, astronautics, missile guidance and mission performance.

Trajectory Analysis
Familiarity with the use of digital computation, analytically inclined, with background in space mechanics.

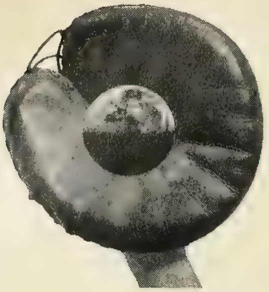
Astrodynamics
Theoretical background in celestial mechanics, orbit determination and/or related fields of math, physics or astronomy.

Guidance Analysis
Familiarity with techniques for missile guidance and experience in orbital mechanics, random processes and statistics.

ACT NOW! Forward your resume immediately to S. A. Shirley at STL's address below.

TRW SPACE TECHNOLOGY LABORATORIES
THOMPSON RAMO WOOLDRIDGE INC

One Space Park – MR-11
Redondo Beach, California
An equal opportunity employer



LOOK AT
LOCKHEED
...IN
GUIDANCE

Research and development in the technology of Guidance is not confined to any one discipline. Broad interests and exceptional capabilities are required, as typified by the following:

GUIDANCE—Ability to formulate guidance laws for missile and spacecraft missions. Familiarity with digital simulation techniques and calculus of variations or methods of steepest descent.

VIBRATION/ACOUSTICS—Develop environment criteria for structural designs from ground and flight data. Advance the state-of-the-art in vibration and acoustical prediction methods.

METEOROLOGY—Perform fundamental studies in turbulence, ground winds, and other natural environments. Understand the latest instrumentation, data acquisition and data analysis techniques.

FLIGHT MECHANICS—Analyze guidance accuracy from tracking data. Apply analog and digital simulation techniques to general vehicle performance studies. Generate mathematical models of dynamic systems.

Inquiries are invited from those scientists and engineers who can make significant contributions to as well as benefit from, advances being made in all areas of Guidance & Controls. Write: Lockheed Missiles & Space Company, Dept. 107, P.O. Box B504, Sunnyvale, California.

LOCKHEED
MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

An equal opportunity employer

Transmission Polariscope

Photolastic, Inc., is marketing a transmission polariscope designed to provide the basic photography of isoclinic and isochromatic fringes, plus five other specialized measurement techniques.

The System Model 060 can perform: measurements using compensation techniques; photometric measurements in both static and dynamic load conditions; strobophotoelastic measurements; oblique incidence measurements (without rotation of a loaded model); and magnification measurements required for analysis in high stress gradient areas.

With the device, it is possible to change operation without resetting the quarter wave plates for every measurement. In isoclinic exploration, the plates automatically follow the angular parameter and, when optically inserted, are in proper position to obtain tardy measurement of fractional fringe orders. Independent rotation of the analyzer is indexed in fractional fringe orders, readable without a vernier to 1/200 of a fringe. The measuring assembly is available with a diffused light system or parallel light system.

Circle No. 158 on Subscriber Service Card

Transducer System

A temperature-to-voltage transducer system with a surface mounting temperature sensor has been developed by Consolidated Controls Corp.

The system provides linear dc output ranging from 0 to 5v over the temperature range of the particular instrument. Input voltage is from 22 to 32v dc with maximum current requirement of 50 milliamps. Units are available for measurements in the 300 to 1,000°F region.

The sensing element consists of patinum wire embedded in silicon-impregnated glass cloth.

Circle No. 159 on Subscriber Service Card

Frequency Meter

Megatronic Instrument Co. is marketing a frequency meter with a range of 400 to 900 mc.

The Model 251 features a sensitivity of 1 mw for 20% meter deflection and accuracy within 2% of reading. The expanded scale covers communication and telemetry bands (400 to 470 mc) that occupy 3 in. of the total 6.5-in. scale length. A patented precision tuning mechanism requires no direct electrical connection to the circuit under test (no insertion loss). Temperature coefficient is negligible.

Circle No. 160 on Subscriber Service Card

Serial Memory System

Three separate and independent digital storage elements, each with a maximum capacity of 8,000 bits, are available in a single memory system developed by Computer Devices Corp.

The MA917 memory consists of magnetostrictive delay lines as the storage element, plus associated input/output circuitry and necessary circuitry for recirculating and reclocking. The unit operates at 2 mc NRZ and has a total maximum storage capacity of 24,000 bits.

Input requirement is 3v at 3 ma. Power required is ±12v. Output is reshaped and reclocked in order to reproduce the input. The system measures 7 x 5.875 x 3 in. and meets applicable military specifications.

Circle No. 161 on Subscriber Service Card

Projection Oscilloscope

Dalto Electronics Corp. is marketing a projection oscilloscope capable of displaying dynamic wave forms, computer data readout or any symbol that can be generated on a standard oscilloscope.

Dalto
Dalto

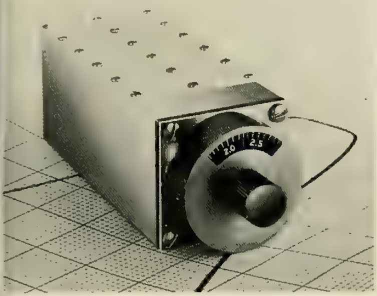
The Model 290 can be used for either front or rear screen projection for pictures from 28 in. up to 12 ft. wide. Separate inputs are afforded for the x, y and z axes ranging from 0.1 to 100v with 100,000-ohm input impedance. Brightness as measured on a 12-ft. standard beaded screen is 4 ft. lamberts with a line width of approximately 160 mils.

Circle No. 162 on Subscriber Service Card

Microwave Filter

Telonic Engineering Co. has available two tunable microwave filters covering the 2 to 4-gc frequency range.

The filters are accurate to within ±1% of the dial setting and are supplied in 3 and 5-section versions. Insertion loss of the 3-section unit is typically 0.4 db, maximum 0.8 db. For the 5-section model, the figures are 0.6 and 1.0 db.



Bandwidths at 3 db for both types is 5% ±1%, maximum VSWR at center frequency is 2:1 and nominal impedance is 50 ohms. Frequency is selected directly by a dial which is a 5:1 vernier type calibrated at 0.1-gc intervals.

Circle No. 163 on Subscriber Service Card

Sinusoidal Accelerator

A dual-function precision accelerator for use in calibrating low frequency dynamic and static acceleration devices is being marketed by Gyrex Corp.

The Model 440 provides up to 1,000 g's of static acceleration or up to 250 g's of sinusoidal acceleration at frequencies from 0.2 to 30 cycles within a 24-in. double amplitude limitation. Test packages up to 10 lbs. and 6 x 6 x 3 in. may be tested in either mode of operation within a 2,000-lb. force limitation. The unit's speed control maintains speed (frequency) constant within 0.005%. Radius (amplitude) is accurate within 0.0005 in.

Circle No. 164 on Subscriber Service Card

Microprobe

Philips Electronic Instruments has announced the Norelco AMR/3 electron probe microanalyzer. The instrument makes direct chemical analysis of a sample, providing qualitative and quantitative data on elemental composition of any specimen area from 1 to 200 microns. Electron microscopy and X-ray spectroscopy techniques are combined to provide analysis in the micro range.

An electron optical system with two magnetic lenses is used to produce an electron focus of 1-2 micron size which excites characteristic X-rays from the specimen. Curved crystal spectrographs are employed to sort the X-rays. An additional scanning goniometer, including detector and analyzing crystal, may be added when desired. Also optional are a beam scanning device, a Kossel line camera and a special X-ray detector for non-dispersive analysis.

The unit accommodates a sample 1 in. in diameter and up to ⅝ in. thick. A light optical system permits observation of the specimen in analyzing position.

Circle No. 165 on Subscriber Service Card

Multichannel Converter

A 3-channel frequency-to-dc converter, featuring wide range selection and optional specific gravity adjustment, has been developed by Foxboro Co.

The FR-523 can accept inputs in any of five ranges, each adjustable over a 4:1 ratio. Each channel can be independently adjusted over ranges from 10-30 up to as wide as 10-12,000 cps.

The unit produces two outputs simultaneously from the selected channel—a 0-5v dc signal with magnitude proportional to input frequency and a square wave with frequency equal to input frequency. Sensitivity can be manually adjusted between 15 mv and 3v peak-to-peak or rolloff circuitry is available. Also optional is an internal frequency source which provides a calibration frequency for each input range.

Circle No. 166 on Subscriber Service Card

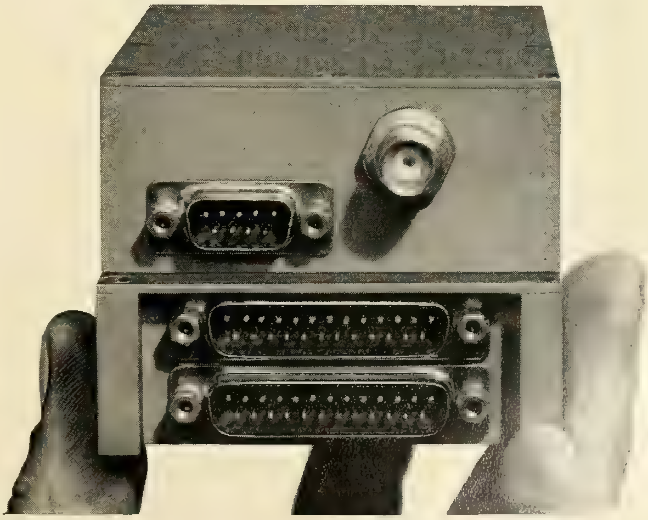
What's NEW at Conic Now?

Command Receivers for Missiles & Spacecraft Conic, the source of the highest reliability in telemetry transmitters, brings you a new line of range qualified Command Receivers.

BRIEF SPECIFICATIONS

TUNING ACCURACY: ±0.005%
LOCAL OSCILLATOR STABILITY: ±0.005%
NOISE FIGURE: 4DB maximum
IMAGE REJECTION: 80DB, meets MIL-I-26600
SPURIOUS RESPONSE REJECTION: 80DB, meets MIL-I-26600
MAXIMUM RF INPUT: 5V RMS
THRESHOLD SENSITIVITY: 1 microvolt for correct relay closure
NUMBER OF CHANNELS: up to 7 (Any IRIG channel, 1 through 20).
RF BANDWIDTH:
Option 1: —3DB = 100KC, —60DB = 300KC;
Option 2: —3DB = 200KC, —60DB = 600KC;
Option 3: —3DB = 300KC, —60DB = 900KC
SIMULTANEOUS USABLE TONES: up to 7
RF DEVIATION REQUIRED FOR PROPER RELAY OPERATION: 9KC (each channel)
INPUT CURRENT: 13 milliamperes + 22 milliamperes for each operated relay at 28 VDC
SIZE: 3.00″ × 4.39″ × 2.47″
For full information write:

CONIC Corporation
7915 Balboa Avenue • San Diego, California 92111



Circle No. 6 on Subscriber Service Card

MISSILES AND ROCKE

HIRD ANNUAL DOD ISSUE, March 29, 1965

advanced technology and the DOD

This issue will concentrate on the application of advanced technology to tactical warfare. It will cover all phases of advanced technology for which the Aerospace Industry has a unique capability including:

Defense level organization involved in tactical warfare • budget for ground warfare • materials • electronics • power sources • basic research • tactical mobility • counterinsurgency • command and control • organization charts • procurement contacts.

Your advertisement in this issue will reach the more than 45,000 program and project managers, engineers and scientists in industry and the military . . . the people responsible for making the important buying decisions.

PLAN NOW TO CAPITALIZE ON THIS UNIQUE EDITORIAL ATMOSPHERE.

M/R

Advertising Closes: March 8, 1965

Issue Date: March 29, 1965

AIRCRAFT ENGINEERS

Seven great aircraft programs open the door to career advancement

More than ten years of intensive engineering activity are on the Douglas agenda. Coming up are extended range DC-8s and DC-8Fs; commercial, business and military versions of the new twin-jet DC-9; a tremendous developmental program on the C-5A, biggest jet in the world; advanced versions of the Navy A-4E and its two-place training counterpart, the TA-4E; and advanced aircraft. And there are other programs we can't talk about.

Right now we are urgently seeking aircraft engineers with BS or advanced degrees who have experience in any of the following: Aerodynamics; Stress Analysis; Load Analysis; Dynamic Analysis; Electrical Design; Structures Design; Power Plant — Thermo-Mechanical; Flight Test Instrumentation; Flight Test Data Analysis; Reliability; Advanced Systems Engineering. Openings include a number of senior positions.

For full information, please send resume to Mr. C. C. Carrico, Professional Employment, Douglas Aircraft Company, 3855 Lakewood Boulevard, Long Beach, California. An equal opportunity employer.

DOUGLAS
AIRCRAFT GROUP

The Industry Week

Mergers and Acquisitions

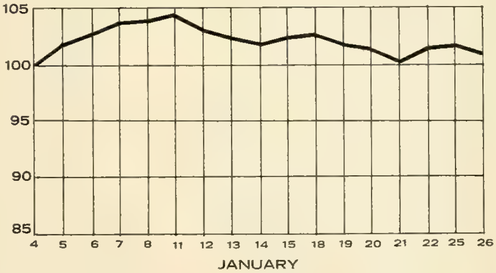
Fairchild Camera and Instrument Corp., Syosset, N.Y., has acquired the assets of White Avionics Corp. of Plainview, N.Y. Fairchild will operate the White plant as the Avionics Plant of its Controls Div. The new plant will produce a vibrating wire, frequency-modulated output accelerometer and pressure transducer, solid-state servo amplifiers, solid-state rotary switches and an optical scanning system that converts shaft rotation to an electrical output in the form of square waves. . . . *Data Control Corp., Minneapolis, expects to acquire Datatrol Corp. early this month. Negotiations are complete and the acquisition lacks only final approval of Datatrol stockholders. Datatrol, located in Silver Spring, Md., produces computer programming systems and provides consulting services for computer users. Data Control has acquired five other firms in the last year: TRG, Inc., an electronics firm; Data Displays, Inc., producers of electronic information display systems; Computer Laboratories, Inc.; Holly Computer Products Co.; and Adcomp Corp.* . . . The boards of directors of Canoga Electronics Corp. and Remanco, Inc., have approved a plan for the acquisition of Remanco's assets by Canoga. The plan calls for Canoga, located in Chatsworth, Calif., to issue one share of common stock for each two outstanding shares of Remanco common in exchange for the assets and liabilities of Remanco. Remanco, Santa Monica, Calif., produces a line of radar test sets, servo-analyzers, voice communications systems, varactor multipliers, video target simulators and related equipment. . . . *Computer Sciences Corp., Los Angeles, has acquired the ITT Communications Systems, Inc., and ITT Intelcom, Inc., subsidiaries of International Telephone and Telegraph Corp. CSI, headquartered in Paramus, N.J., is occupied in the design and development of a global communications network for the Air Force. It is also under contract to the Defense Communications Agency for systems analysis and computer simulation of the Defense Communications System. The other acquisition, located in Falls Church, Va., is engaged in engineering and systems management services in the field of communications satellites.*

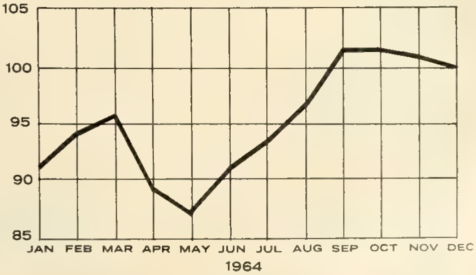
New Facilities

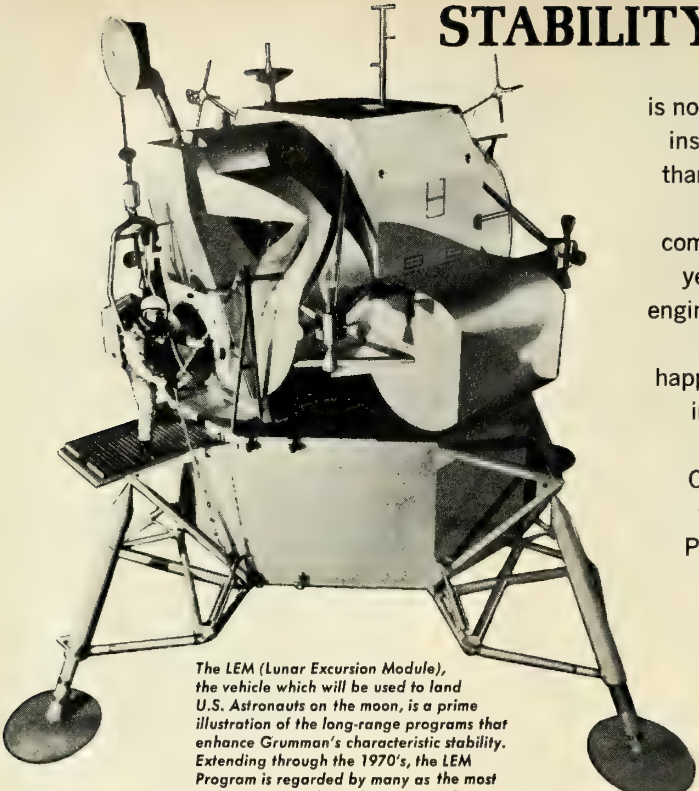
Bunker-Ramo Corp., Canoga Park, Calif., has created a General Engineering Lab within its Defense Systems Div., which will combine the functions of product design for the Western Technical Center, material and devices development, system effectiveness in engineering design and development, value engineering and cost reduction, and man-machine control system research. . . . *Synergy Chemicals, Inc., has moved into a new technical center in Linden, N.J. SCI, founded six months ago, manufactures high performance thermosetting polymeric products and assists industry in solving applications problems involving epoxy adhesives, urethane foams and special purpose coatings.* . . . Signetics Corp. has dedicated a new $5-million, 100,000-sq.-ft. manufacturing complex at Sunnyvale, Calif. Signetics, a subsidiary of Corning Glass Works, manufactures semiconductor integrated circuits.

Missile/Space Stock Index

This issue of MISSILES AND ROCKETS introduces a new Industry Week feature, the Missile/Space Stock Index, designed to reflect the activity of aerospace and defense stocks on Wall Street during the four-week period ending on M/R's weekly closing date. The weighted index was developed by M/R's companion publication, *Missile/Space Daily* and the M/R research department. Firms whose stocks are reflected in the index meet the following criteria: annual sales volume of $200 million or more; do more than half their business with the defense/space industry; and are traded on the New York Stock Exchange. Presently included in the index are: Avco, Bendix, Boeing, Douglas, General Dynamics, General Precision, Grumman, Lear Siegler, Ling-Temco-Vought, Litton Industries, Lockheed, Martin Marietta, McDonnell, North American Aviation, Northrop, Raytheon, Thiokol, Thompson Ramo Wooldridge and United Aircraft. Not to be included are firms undergoing major changes in organization or ownership plans that might cause temporary fluxuation in their stock prices. The index is based on closing market prices on Dec. 31, 1964, represented by the figure 100. Weighting factors are worked out to prevent stock price changes for any one company from having an inordinate effect on the total. Stock market prices are furnished by Merrill Lynch, Pierce, Fenner, and Smith.







STABILITY AT GRUMMAN

is not an abstract. It's a way of life. Some for instances. Our annual turnover rate is less than one quarter of the rest of the industry. 55% of our people have been with the company for more than five years. 37% ten years or longer. 19% over 15 years. Some engineers have been with the company since it started thirty-five years ago. A lot has happened since. We got up to our "fuselage" in military aircraft . . . in Anti-Submarine Warfare . . . in Early Warning . . . in Commercial Aircraft . . . in Space. Where will it end? Maybe on Mars somewhere. Professional verve with 'built-in' stability. That's the word at Grumman. Investigate challenging opportunities in the following areas.

The LEM (Lunar Excursion Module), the vehicle which will be used to land U.S. Astronauts on the moon, is a prime illustration of the long-range programs that enhance Grumman's characteristic stability. Extending through the 1970's, the LEM Program is regarded by many as the most ambitious technological endeavor of our times.

THERMAL CONTROL & PROPULSION
- Heat Transfer & Thermo Dynamics
- Rocket System Performance Analysis
- Fluid Mechanics/Gas Dynamics

SYSTEMS ANALYSIS
- Mission Analysis
- System Synthesis & Analysis
- Data Processing Systems
- Systems Integration
- Sensor Systems
- Control Systems
- Systems Simulation
- Programming
- Programming Analysis
- Systems Test Planning & Coordination

ELECTRONIC SUPPORT ENGINEERING
- Digital Logic Design
- Analog Simulation & Analysis
- Transistor Power Supply & Control
- Switching Logic
- Video Simulation
- Electronic Laboratory Development
- Circuit Design

STRUCTURES ENGINEERING
- Stress Analysis
- Structural & Environmental Testing
- Structural Methods & Development

FLIGHT TEST
- Systems Design
- Flight Operations
- Measurements & Transducers
- Installation
- Test Facilities
- Program Analysis & Support
- Ground Station Data Handling

(FOLLOWING AREAS, BOTH LOCAL AND FIELD ASSIGNMENTS)
- Facility Activation
- Pre-Launch Check-out Planning & Testing
- Spacecraft Mission Planning & Analysis
- Flight Development Test Planning & Analysis

DYNAMIC ANALYSIS
- Acoustics & Environmental Vibration
- Guidance Dynamics

MECHANICAL SUPPORT ENGINEERING
- Cryogenics, Environmental Control & Propulsion Equipment
- Mass Properties
- Requirements
- Visual Training
- Design

WEIGHT CONTROL
- Optimization & Analysis

RF ENGINEERING
- Radar
- RF Interference
- RF Systems Analysis
- RF Communications
- ECM

SERVO ENGINEERING
- Power & Instruments
- Navigation & Controls

COMPUTER ENGINEERING
- Programming
- Computer System & Hardware Design

ELECTRONIC LIAISON TEST
- Radar
- Digital Computers
- Inertial Systems
- Electronic Field Engineering

RELIABILITY CONTROL
- Reliability & Maintainability Engineering
- Reliability Test
- Reliability Statistics

VEHICLE ELECTRICAL DESIGN
- Electro/Mechanical Design

To arrange an immediate interview,
SEND RESUME to
Mr. P. M. Van Putten,
Manager Engineering Employment,
Dept. GR-86

Grumman
GRUMMAN
AIRCRAFT ENGINEERING CORPORATION
Bethpage • Long Island • New York
An Equal Opportunity Employer

Circle No. 1 on Subscriber Service Card

contracts and procurements

AWARDS

AIR FORCE

$3,500,000—**General Telephone and Electronics Corp.**, a Sylvania Electric Products, Inc., subsidiary, New York City, for work on an improved electronic security system for *Minuteman* missile sites.

$2,921,000—**Thiokol Chemical Corp.**, Huntsville, Ala., for production of solid-propellant rocket motors.

$1,410,000—**Martin Marietta Corp.**, Littleton, Colo., for production of range safety kits for *Titan II* missiles.

$1,315,957—**General Motors Corp.**, Milwaukee, for research and development work on an inertial guidance system for the *Titan II*.

$1,000,000—**Thiokol Chemical Corp.**, Brigham City, Utah, for continued research and development work on first stage motors for *Minuteman* missiles.

$785,000—**United Aircraft Corp.**, United Technology Center Div., Sunnyvale, Calif., for one-third year of work under R&D of hybrid rocket program, raising total funding to more than $1.8 million.

$306,000—**The Boeing Co.**, Aero-Space Div., Seattle, for fluidized bed techniques for coating refractory metals.

$191,230—**Aerojet-General Corp.**, Solid Rocket Plant, Sacramento, Calif., for advanced binder for high-energy solid propellants.

$123,410—**General Precision Inc.**, Link Group Systems Div., Binghamton, N.Y., for maintenance of flight simulator at AF Rocket Propulsion Lab, Edwards AFB, Calif.

$97,404—**Bendix Corp.**, Bendix Systems Div., Ann Arbor, Mich., for magnetic window propagation.

$35,181—**Systems Technology Inc.**, Inglewood, Calif., for effect of nonlinearities on tracking performance.

ARMY

$6,638,864—**Hercules Powder Co.**, Wilmington, Del., for propellants for the *Honest John* and the *Little John* rockets and *Nike* boosters.

$2,900,000—**Ling-Temco-Vought, Inc.**, Dallas, for work on a classified R&D project.

$1,559,109—**Standard Oil Co. of New Jersey**, Linden, N.J., for continued R&D on high-performance propellants.

$600,000—**Radio Corp. of America**, Moorestown, N.J., for the *AADS-70* program.

$303,634—**Tri-Central Construction Co.**, Fresno, Calif., for additions to *ABRES* test facility II at Vandenberg AFB, Calif.

$46,510—**Battelle Memorial Institute**, Columbus, Ohio, for 12-month research work leading to development of a multi-fueled thermal energy conversion system, including sample burner and tech reports.

NAVY

$18,715,692—**Goodyear Aerospace Corp.**, Akron, Ohio, for *Subroc* Mk 28 Mod O and associated equipment.

$18,500,000—**Raytheon Co.**, Portsmouth, R.I., to make sonar sets for nuclear attack submarines.

$11,355,134—**Vitro Corp. of America**, Silver Spring, Md., for engineering work on *Terrier*, *Tartar* and *Talos* missiles.

$3,795,000—**General Electric Co.**, Ordnance Dept., Pittsfield, Mass., for field engineering services for installation, test, repair, modification and other engineering support of *Polaris* fire control, guidance and related support equipment.

$1,277,031—**Sperry Rand Corp.**, Bristol, Tenn., for production of *Shrike* air-to-surface missiles.

$1,250,000—**Lear Siegler, Inc.**, Santa Monica, Calif., to provide torpedo-guidance servo actuators for the Mark-37 and -45 torpedoes.

$510,000—**Milgo Electronic Corp.**, Miami, Fla., for two contracts to design, develop and manufacture two data systems, part of the AUTEC program.

$273,835—**General Electric Co.**, Ordnance Dept., Pittsfield, Mass., for *Polaris* Mk 2 guidance tests and support equipment.

$200,000—**Goodyear Aerospace Corp.**, Akron, Ohio, for field engineering services for providing technical assistance and instruction in connection with test, installation, repair and servicing of underwater weapons, *Subroc* missile system.

$157,505—**H.C.H., Inc.**, Honolulu, for satellite tracking facilities, Pacific Missile Range, Naval Communication Station, Honolulu.

$150,677—**Edwin A. Keeble Associates, Inc.**, Nashville, Tenn., contract modification to increase the scope of the contract for preparation of logistics information in support of maintenance and production of surface missile system.

$116,000—**Philco Corp.**, Communications and Electronics Div., Philadelphia, for services and materials for repair and/or modification of *Sidewinder IC* guidance and control groups.

$61,465—**Massachusetts Institute of Technology**, Cambridge, Mass., to extend level of effort of studies concerned with development of an underwater missile depth control system.

$49,865—**Worcester Polytechnic Institute**, Worcester, Mass., for studies and tests to determine missile behavior during water entry, water exit, trajectories in underwater travel and launching from moving underwater platforms.

$28,808—**Perkin-Elmer Corp.**, Norwalk, Conn., for research to produce a far-infrared generator based on mixing two IR semiconductor lasers.

NASA

$5,178,000—**Blount Bros. Corp.**, Sandusky, Ohio, for construction of an aluminum test chamber.

$2,425,000—**Radio Corp. of America**, Princeton, N.J., for single camera advanced vidicon camera systems.

$337,274—**Honeywell Inc.**, St. Petersburg, Fla., for definitization of letter contract for *Centaur* guidance GSE for Eastern Test Range complex 36B and combined systems test.

$311,700—**General Electric Co.**, Philadelphia, for *Nimbus C* data system computer program.

$192,000—**Hughes Aircraft Co.**, Research Laboratories Div., Culver City, Calif., for the first phase of a research program on gravitational mass sensors.

$173,000—**Whirlpool Corp.**, Systems Div., St. Joseph, Mich., for *Gemini* flight food.

$101,760—**Vitro Corp. of America**, Vitro Laboratories Div., West Orange, N.J., for timing systems equipment.

$99,500—**Lockheed Electronics**, Edison, N.J., for PCM Class 1 digital modular spacecraft tape recorders.

$97,750—**Beckman Instruments, Inc.**, Systems Div., Fullerton, Calif., for data acquisition system.

$95,823—**Radio Corp. of America**, Communications Systems Div., Princeton, N.J., for research for analysis of radiation damage in silicon solar cells and the annealing or compensation of the damage by impurities.

$80,000—**Bureau of Naval Weapons**, Washington, D.C., for orbital otolith experiment.

$69,800—**General Dynamics/Astronautics**, San Diego, for storage, preservation, maintenance and inspection for four *Mercury*-type *Atlas* series D boosters.

$66,883—**Radio Corp. of America**, Communications Systems Div., Tucson, Ariz., for a remote cable pressure monitoring system.

INDUSTRY

$1,250,000—**Lear Siegler, Inc.**, Power Equipment Div., Cleveland, Ohio, from the **U.S. Navy** and **Westinghouse Electric Corp.**, Undersea Div., Baltimore, two contracts for torpedo guidance actuators.

$1,100,000—**Electronic Specialty Co.**, Electronics Div., Los Angeles, from **Tasker Instruments Corp.**, Van Nuys, Calif. and **Metric Systems Corp.**, Fort Walton Beach, Fla., for two contracts for antenna pedestals and subsystems.

$991,320—**Radio Corp. of America**, Communications Systems Div., Camden, N.J., from the **Government of India** for AN/PRC-25 Tactical Radio Transceivers.

$532,000—**Electronic Memories, Inc.**, Hawthorne, Calif., from **The Boeing Co.**, Seattle, for memory devices for the flight programmer on *Lunar Orbiter* spacecraft.

$200,000—**Swedlow, Inc.**, Garden Grove, Calif., from **Aerojet-General Corp.**, Sacramento, Calif., for the procurement of an undisclosed number of reinforced plastic altitude exit cones for the *Minuteman* ICBM.

$141,000—**Raymond Engineering Laboratory, Inc.**, Middletown, Conn., from **Sandia Corp.**, Albuquerque, N.M., for fabrication of inertial switches.

NATIONAL SCIENCE FOUNDATION

$97,000—**University of Colorado**, Boulder, for a study of the interactions and motion of the atmosphere high above the Earth.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

Negotiations will be conducted with the Aluminum Company of America for a continuation of an investigation of the stress corrosion cracking of high strength aluminum alloys. For information only; RFP not available.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

A six-month study of the optimization of welded joint design and further analyses of honeycomb sandwich joints to determine the effect of design and fabrication variables on the efficiency of the composite joint is being sought. RFQ due date is Feb. 22, 1965; RFQ DCN 1-5-30-12528.

Procurement Division
Bldg. 5603
Aberdeen Proving Ground, Maryland

Negotiations are being conducted with Space Instruments Research Inc., Atlanta, for participating in firing probes. This is a continuation of services conducted under Contract DA-01-009-AMC-169(X)—RFQ-RD-APG-167-65. This notice does not solicit additional proposals but is issued for the benefit of prospective subcontractors.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

Negotiations with the American Machine and Foundry Co. will be conducted for continuation of the development of lightweight magnesium for low-temperature applications. For information only; RFP not available.

Space Systems Division
Air Force Systems Command
Los Angeles, California

Follow-on contract award to Rocketdyne Division, North American Aviation, Inc., for test program on MA-5 *Atlas* propulsion system. For information only; RFP not available.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

RFQ DCN 1-5-30-12529-01 due Feb. 25, 1965, for an alternate development of *Saturn* manufacturing technology for welding methods and techniques. It is estimated that the period of performance will be nine months.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

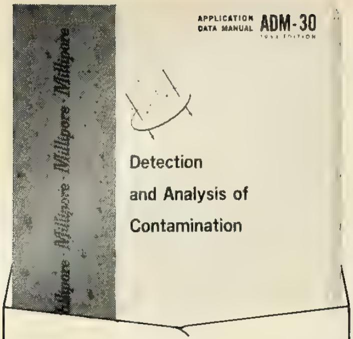
A nine-month study to develop beryllium end fittings for beryllium structural tubing will be sought by the Center. RFQ DCN 1-5-30-12530-01, due date Feb. 25, 1965.

Lewis Research Center
National Aeronautics and Space Administration
21000 Brookpark Road
Cleveland, Ohio 44135

RFP was issued during week of Jan. 25 for a program of research, development and testing of mainshaft seals suitable for use in advanced air breathing propulsion systems. RFP 202989.

Lewis Research Center
National Aeronautics and Space Administration
21000 Brookpark Road
Cleveland, Ohio 44135

RFP 202993 was issued during week of Jan. 25 for a program of research leading to a determination of methods for predicting thermal stress cracking in turbine stator or rotor blades.


APPLICATION DATA MANUAL ADM-30
Detection and Analysis of Contamination
Millipore

Worth writing for

ADM-30, Detection and Analysis of Contamination outlines the measurement of particulate contamination with Millipore filters as applied to hydraulic fluids, air, fuels, lubricants, solvents, garments, surfaces and other aerospace and industrial fluids. To receive a free copy of this 44-page manual, write to

Millipore®
FILTER CORPORATION
200 Ashby Road, Bedford, Mass.

(Millipore® filters are cellulose plastic porous membranes made in twelve pore-size grades from 8 microns down to 10 millimicrons. In microfiltration or analysis, all matter larger than the filter pore size is screened from fluids and retained on the filter surface.)

Circle No. 3 on Subscriber Service Card

Advertiser's Index

AVCO RESEARCH & ADVANCED DEVELOPMENT, A DIV. OF AVCO CORP. 48
Agency—Benton & Bowles, Inc
BOEING CO., THE, AIRPLANE DIV. 18
Agency—Campbell-Ewald Co
BROWN ENGINEERING CO., INC. 4
Agency—Smith-Kirkpatrick Adv., Inc.
COMPUTER SCIENCES CORP. 24, 25
Agency—Hal Stebbins Inc
CONIC CORP. 37
Agency—Teawell, Inc
DOUGLAS AIRCRAFT CO., INC. 40
Agency—J. Walter Thompson Co
GENERAL ELECTRODYNAMICS CORP. .. 6
Agency—Glenn Adv., Inc
GRUMMAN AIRCRAFT ENGINEERING CORP. 42
Agency—Newmark, Posner & Mitchell, Inc
HUGHES AIRCRAFT CO. 47
Agency—Foote, Cone & Belding
JET PROPULSION LABORATORY 33
Agency—Hixson & Jorgensen, Inc
LOCKHEED MISSILES & SPACE Co. 36
Agency—Hal Stebbins Inc.
MILLIPORE FILTER CORP. 44
Agency—Culver Adv., Inc.
SPACE TECHNOLOGY LABS., A SUB. OF THOMPSON RAMO WOOLDRIDGE INC. 35
Agency—Fuller & Smith & Ross Inc
SPERRY GYROSCOPE CO. DIV. OF THE SPERRY RAND CORP. 2
Agency—Reach, McClinton & Co., Inc
VICKERS INC., ELECTRIC PRODUCTS DIV., A DIV. OF THE SPERRY RAND CORP. 5
Agency—Tobias & Olendorf, Inc

names in the news

McCULLOUGH

JOHNSON

WHITLEY

FOGG

Dr. Ivar Giaever: Awarded the 1965 Oliver E. Buckley Solid State Physics Prize of The American Physical Society for his discovery that electrons can tunnel through a simple insulating layer only 10 to 100 atoms thick between two thin films. He is a physicist at the General Electric Research Laboratory.

Foy McCullough, Jr.: Elected vice president of Rocket Research Corp., Seattle. He was previously with the Naval Ordnance Test Station. Also elected a vice president was **Louis R. Viggiano,** formerly with Lockheed Missiles and Space Co.

Robert L. Johnson: Selected to head new manned spacecraft programs organization of Douglas Aircraft Co.'s Missile & Space Systems Div. He was named a vice president-director, along with **Stephen P. Dillon** as director of procurement and production, and **Dr. Allen F. Johnson** as director of systems development and engineering for the new organization.

Robert Whitley: Named deputy project manager of the Army Missile Command's *TOW* weapon system. He was formerly chief of the development division's *TOW* branch in the directorate of research and development.

Dr. Robert W. Rector: Appointed chairman of the 1965 Fall Joint Computer Conference by **Dr. Edwin L. Harder,** chairman of the governing board of the American Federation of Information Processing Societies, sponsors of the conference. Rector is with the Aerospace Corp. as assistant director of the computation and data processing center.

Philip S. Fogg: Elected chairman of the executive committee of the Lear Siegler, Inc., board of directors. He has been a director of the company since its formation in 1954.

Dr. Henri Busignies: Elected a senior vice president of the International Telephone and Telegraph Corp. Inventor, scientist and an authority on direction finders, he holds more thain 140 patents in the air navigation, radar and communications fields.

Lawton M. Hartman, III: Appointed by Librarian of Congress L. Quincy Mumford to the staff of the science policy research division in the legislative reference service at the Library of Congress. Formerly with the Department of Defense, he will serve as a senior specialist in science and technology.

William S. Mahoney: Elected a vice president of Federal-Mogul-Bower Bearings, Inc., and appointed group manager of the bearings group.

Edward J. Williams: Named general vice president of manufacturing and facilities for Rockwell Standard Corp. He was formerly vice president and general manager of the Aero Commander Div.

Grover D. Nobles, Jr.: Appointed corporate publicity manager of the Lockheed Aircraft Corp. He was formerly news bureau manager for the Lockheed-California Co. He replaces **Warren Hughes,** who resigned to become president of Intercontinental Public Relations, Inc.

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Geneva, Switzerland—10 Rue Grenus; Geneva 321044

Paris, France—11 Rue Condorcet; TRU 15-39

—when and where—

FEBRUARY

Sixth Annual Solid Propellant Rocket Conference, sponsored by the American Institute of Aeronautics and Astronautics, Mayflower Hotel, Washington, D.C., Feb. 1-3.

Estimating and Evaluating Research and Development Costs, sponsored by the National Defense Education Institute, New York City, Feb. 2-4.

Symposium in On-Line Computing Systems, sponsored by Informatics Inc. and the University of California at Los Angeles, Schoenberg Hall, UCLA campus, Los Angeles, Feb. 2-4.

Reinforced Plastics Division Conference, sponsored by the Society of the Plastics Industry, Edgewater Beach Hotel, Chicago, Feb. 2-4.

Winter Convention on Military Electronics, sponsored by the Institute of Electrical and Electronics Engineers, Ambassador Hotel, Los Angeles, Feb. 3-5.

Unmanned Exploration of the Solar System, sponsored by the American Astronautical Society, the American Astronomical Society, American Geophysical Union, American Institute of Biological Sciences, IEEE and AIAA, Denver Hilton Hotel, Denver, Feb. 8-10.

Spring Meeting of the American Society for Testing and Materials, Statler-Hilton, Cleveland, Feb. 8-12.

50th Norelco X-ray Analytical School, Willard Hotel, Washington, D.C., Feb. 8-12.

Flight Testing Conference sponsored by the AIAA and NASA, Huntsville, Ala., Feb. 15-17.

Third Annual Conference of the Electronic Sales-Marketing Assn., Summit Hotel, New York City, Feb. 15-17.

1965 Electrical and Electronic Trade Show, sponsored by the Electrical Representatives Club and the Electronic Representatives Assn., Denver Auditorium Arena, Denver, Feb. 15-17.

Fourth Annual Photo-optical Workshop and Product Display, sponsored by the Society of Photo-optical Instrumentation Engineers, Statler Hilton Hotel, New York City, Feb. 17.

International Solid State Circuits Conference, sponsored by the University of Pennsylvania and IEEE, Sheraton Hotel, Philadelphia, Feb. 17-19.

Annual Meeting of the United States Naval Institute, U.S. Naval Academy, Annapolis, Md., Feb. 18.

National Air Meeting of the Institute of Navigation, in conjunction with the Army, Navy and Air Force (classified confidential), State Department Auditorium, Washington, D.C., Feb. 18-19.

Sixth Annual West Coast Reliability Symposium, sponsored by the American Society for Quality Control and UCLA Engineering Dept., UCLA campus—Moore Hall, Los Angeles, Feb. 20.

PRACTICAL PERT
$2.75
Including CRITICAL PATH METHOD
B. J. HANSEN
A STEP-BY-STEP GUIDE
How to use today's foremost management tool to increase profits and industrial efficiency
AMERICA HOUSE

FOR ALL LEVELS OF MANAGEMENT

offered for the first time

$2.75

by B. J. HANSEN
(member of the original Polaris-PERT Team)

You get the complete **PERT** system and, for the first time, a **PERT** technique showing you how to predict and monitor profit on a continuing bi-weekly cycle.

Chapter XI, "Profit **PERT** and Incentives," brings you the Martin Company case history showing how the Titan III **PERT**-profit system works: In the words of Secretary of Defense Robert McNamara, "(Titan III) is probably the best managed contract we have, and it is the best managed almost entirely because of the tremendous incentive given to that contractor in the form of potential profit increases to hold his costs down."

PRACTICAL PERT tells how and when to meet contract obligations, how to keep programs on schedule, how to win highest incentive fees. **PERT**, developed for the nation's defense programs, can be applied to management operations to monitor profit as well as cost, time and performance in the fields of construction, chemical processing, manufacturing . . . and wherever complex systems are involved.

PRACTICAL PERT contents

I INTRODUCTION TO PERT
II THE ABC'S OF PERT
III PERT & TIME
IV HOW PERT PLANS
V HOW PERT CONTROLS
VI BUILDING PERT
VII WHAT IS NETWORKING
VIII REFINING THE NETWORK
IX MEASURING MANAGEMENT RISK
X PERT & COST
XI PERT COSTS & COMPUTERS
XII PROFIT PERT & INCENTIVES
XIII PERT DATA DISPLAY

AMERICA HOUSE
1001 Vermont Avenue, N.W., Washington, D.C. 20005

Send Me ☐ Copies of Practical Pert
$2.75
.25c Handling
$3.00

☐ Check Enclosed ☐ Bill Me

Name________________ Job/Title________________

Address________________ City________________

Zip Code__________ State__________ Co. Name________________

Behind the Budget

THE MOST SIGNIFICANT ASPECT for this industry of the budget which President Johnson has sent to the Hill is the firm commitment by the Administration to military development of the *Manned Orbiting Laboratory* (*MOL*).

This is of particular importance because it reflects a Presidential decision on the relative roles NASA and the military will play in space for the remainder of this decade.

To understand this, it is first necessary to take a close look at just what has happened in the *MOL* program itself. The industry has been requested to submit proposals for design studies "to assist in developing the cost and technical information required to proceed with full-scale development of the military *Manned Orbiting Laboratory (MOL)*."

It is the specifically stated intent of the Dept. of Defense to choose the contractor who will develop and build the *MOL* from one of the three selected to do the design studies. *MOL* thus is already in what DOD officials call the pre-program definition phase.

That this is not in any way another delay pending further argument or discussion of the project was made amply clear by a high Defense Dept. spokesman who answered just that question. He said:

"It is not another look. We are progressing every month toward development of specific hardware. But there is probably a billion dollars of cost associated with any form of a *Manned Orbiting Laboratory* program. I use that figure very loosely because we don't have any final cost estimates associated with it yet. But a billion dollars of cost associated with an uncertain military requirement. We are not going to proceed without knowing very clearly what we are buying, why we are buying it and what we expect to gain in the way of military applications."

He then was asked: "Can you give us a timetable about when the decision will be let on which contractors get the study, when they will be expected to return their studies and when you will make the final decision to go ahead?"

The answer was: "All of that we expect to accomplish this year, calendar year."

It was made clear that plans to use the *Gemini B/ Titan III-C* combination are being continued, that Fiscal 1965 money is in fact already being devoted to that end in order to assure the option of maintaining an initial 1968 launch date.

Top defense officials were quite unequivocal in their statements about *MOL* and support for the program as it is progressing seems unqualified.

The new look of the *MOL* program that is of extreme importance is its broadened nature. This is what the DOD press release had to say concerning that:

"The program, to determine the military man's potential usefulness in space, will encompass development of technology to improve the capabilities for manned or unmanned operation of military significance. It will also include development and demonstration of manned assembly and service in orbit of large structures with potential military applications and may include intermediate steps toward operational systems."

On that subject, the high DOD official said this: "One thing we have done with the orbital laboratory —and you may have noticed I used the term orbital laboratory rather than manned orbital laboratory this morning—is to broaden its concept to include unmanned activities as well as manned. We have not eliminated the manned phase of the program, but we have added to it a large payload of unmanned activities and operations."

What about these unmanned experiments?

"The purpose of those experiments would be to use the very large payloads that are made available by any booster that also can put up a man, since man takes a lot of payload, to try to do the things that can be done well in space: observation, weather, the various things that you have heard of before."

It was also clear that in carrying out the program DOD intends to make use of any already-developed components, just as it is doing with the *Gemini/ Titan* combination. In other words, if somewhere down the road use of a *Saturn* or an *Apollo-X* appears attractive, then these vehicles will be procured from NASA, which is developing them for its own purposes.

BEHIND ALL OF THIS is the fact that this phase of our space exploration now definitely has been assigned to the military to meet military needs. First of these needs is to determine just what role a military man can play in space and whether he can meet the requirements better than an unmanned system.

The decision was not reached lightly, as there was some duplication of the goals NASA hoped to reach for over the next several years. The President has decided that there is not enough money for both and that the Air Force will proceed with this large-scale new project while NASA continues to work at the objectives already set for it in the lunar landing program.

This is just as it should be. NASA has its hands full at the moment with the *Apollo* commitment, and adding further large-scale programs could interfere with that task. The space agency has been told, in effect, to lower its sights a little and take a look at those things it can do with the hardware already under development—that is, a two-week stay-time on the Moon and four-to-six-week orbital experiments, employing *Apollo* and *Saturn;* not at large, expensive manned lunar bases or at giant, wheeling 35-to-40-man orbital space stations. The military, meanwhile, will push ahead to explore and fulfill its own requirements.

This is a decision which is likely to gain favor with Congress and one we heartily support.

William J. Coughlin

[illegible]

Systems Analysts & Preliminary Design Engineers for Advanced Space Guidance & Control Systems

Rapid expansion of space contracts, projects and studies at the HUGHES Aerospace Divisions in Southern California has created unusual opportunites for several qualified Engineers, Physicists and Mathematicians for Advanced Space Systems assignments.

Space-mission openings are available in the following areas:

- **INTERPLANETARY GUIDANCE & NAVIGATION**
- **TRANS-LUNAR GUIDANCE & NAVIGATION**
- **EARTH ORBIT NAVIGATION**
- **RENDEZVOUS & RE-ENTRY GUIDANCE**

Current requirements include:

Guidance & Navigation System Synthesis

To study and develop guidance and navigation equations and techniques; make feasibility and error analyses; establish system and component requirements; conduct system preliminary design; plan inertial, optical and electro-magnetic instrumentation.

Control System Synthesis

To analyze control system requirements for various space vehicles; establish subsystem and component requirements; conduct system preliminary design; study measurement instrumentation and torque-producing equipment.

Simulation

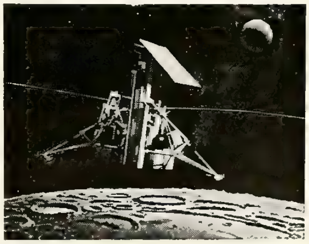
To plan digital simulation for studies related to earth orbital, trans-lunar, interplanetary and re-entry trajectories; analog simulation of rendezvous guidance and control systems.

Applied Mathematics

Space mathematics applications related to orbit determination, trajectory analysis, optimization procedures, perturbation theory and space mechanics.

If you hold an accredited Engineering, Physics or Mathematics degree, are a U. S. citizen and feel that you are qualified by interest and experience in one or more of these areas, please airmail your resume to:

MR. ROBERT A. MARTIN
Head of Employment
HUGHES Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 17, California



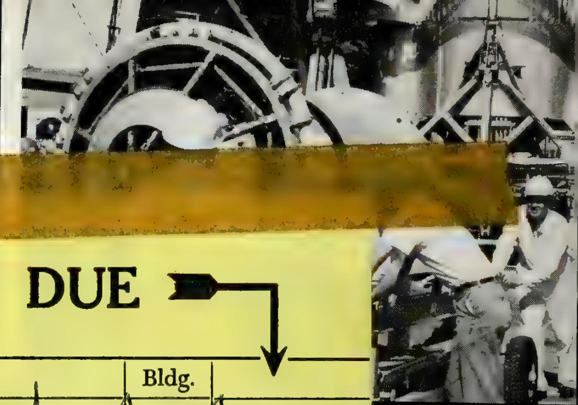
WE PROMISE YOU A REPLY WITHIN ONE WEEK.

An equal opportunity employer.

Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS



DATE DUE

cs

Borrower	Bldg.	
[illegible]		FEB 8 1965
[illegible]	NSP 67	APR 12 1965
Periodical Library	172 BASEMENT	
Periodical Library	172 BASEMENT	
Periodical Library	172 BASEMENT	

PICATINNY ARSENAL
TECHNICAL INFORMATION SECTION
(LIBRARY)

SMUPA FORM NS 677 OCT 62 1-65

Flights:

At Cape Ken
Avco/RAD fl

This is "hardware flyin
the job they're intende
Sands check out and n
launch, flight, and re-
complete evaluation o
the laboratory, solving
ricate full-scale vehicle
That's what we mean w

e vehicles do
FB, and White
ehicle during
quarters for
e start off in
ock-ups, fab-
cle systems.
organization.

RESEARCH AND ADVANCED

CO

FEBRUARY 8, 1965

missiles and rockets

HE WEEKLY OF ADVANCED TECHNOLOGY

FEB 1965
HOUSTON PUBLIC
LIBRARY
Houston Texas

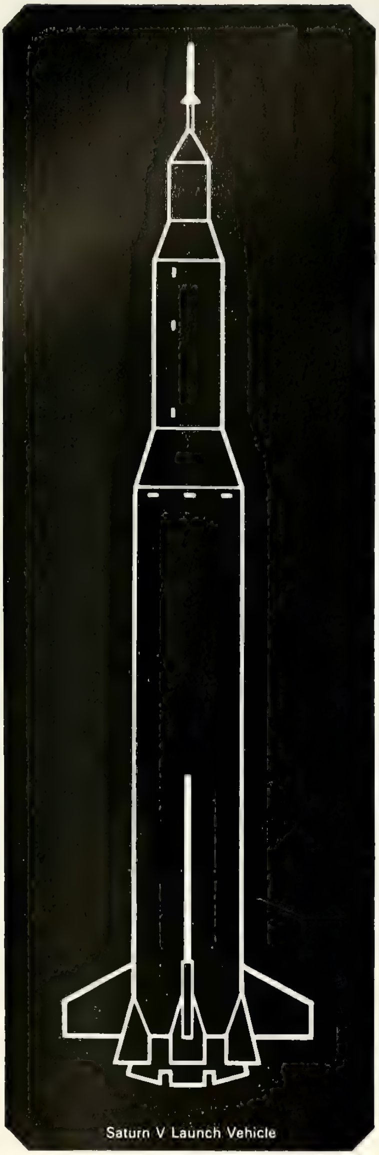
Fluidic Logic Plane from Martin-Orlando

ABRES Yields Re-entry Scaling Laws . . .

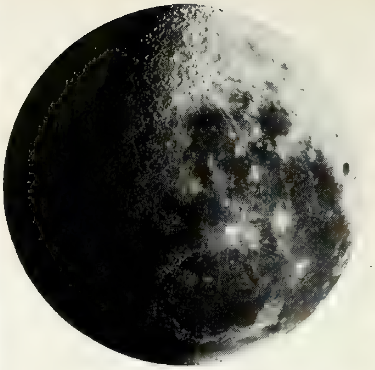
SPECIAL REPORT—

The Fast-Growing Field of Fluidics . . . .

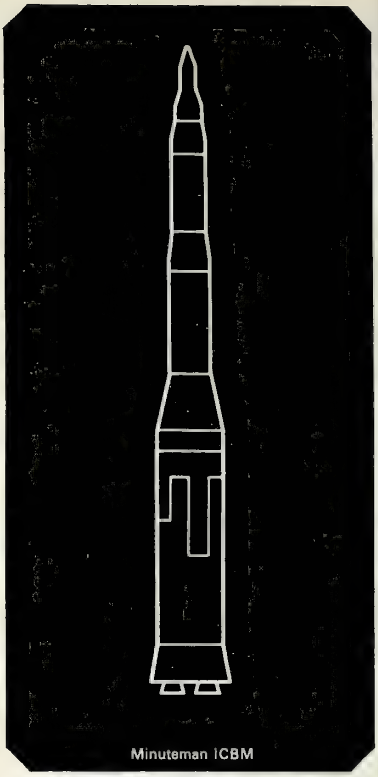
TION



Saturn V Launch Vehicle



Lunar Orbiter



Minuteman ICBM

Manned Orbital Laboratory

Space Research

Space-Age Boeing Openings for Engineers and Scientists

The Boeing Company's Aero-Space Division, major contractor for the Saturn V launch vehicle, Minuteman ICBM and the lunar orbiter, has a number of challenging opportunities for graduate engineers and scientists. (See list in right-hand column.) Assignments, which vary with each Boeing facility, are at Cape Kennedy, Fla.; Huntsville, Ala.; New Orleans, La.; Seattle, Wash., and Vandenberg AFB, Calif.

Minimum requirements are a B.S. degree in an engineering or science discipline, plus applicable experience. Salaries are commensurate with your experience and education background. Travel and moving allowances are paid to newly hired personnel. Boeing is an equal opportunity employer.

Send your resume today to the employment manager at the installation(s) you prefer: Mr. L. S. Bonsteel, Boeing Atlantic Test Center, P. O. Box 1698 - MSW, Cocoa Beach, Fla.; Mr. John Hall, Boeing Launch Systems Branch, P. O. Box 1680 - MSW, Huntsville, Ala.; Mr. L. Wendell Hays, Boeing Launch Systems Branch, P. O. Box 29100 - MSW, New Orleans, La. 70129; Mr. John H. Taylor, Boeing Pacific Test Center, P. O. Box 1626 - MSW, Vandenberg AFB, Calif., or Mr. Lawrence W. Blakeley, The Boeing Company, P. O. Box 3822 - MSW, Seattle, Wash. 98124.

Systems Engineering • Flight Technology • Telemetry Design • Electronics Technology • Instrumentation • Propulsion and Mechanical Systems • Scientific Computer Programming • Logistics Engineering • Aerospace Program Planning • Metallurgy • Test Engineering • Electrical/Electronic Design • Materials & Processes • Human Engineering • Cryogenics • Weights Engineering • Guidance & Control • Reliability • Service Engineering • Mechanical Design • Structures Analysis & Design • Computer & Logic Circuit Development • Industrial Engineering • Electronic/Electromechanical Parts Evaluation • Programmers and Systems Analysts

BOEING

Divisions: Commercial Airplane • Military Airplane • Turbine • Vertol • **AERO-SPACE** • Also, Boeing Scientific Research Laboratories

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 6 February 8, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors

Charles D. LaFond .... Electronics
William S. Beller .... Engineering

Associate Editors

Lawrence J. Curran ...... Assistant Managing Editor
Heather M. David .... Space Medicine
Michael Getler .... Electronics
Russell Hawkes .... Industry
John F. Judge .... Advanced Materials
Robert L. Parker .... Copy Editor
Rex Pay .... Electronics
Hal Taylor .... NASA
James Trainor .... Military

Contributing Editors

David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach .... Art Director
Donald Strickland .... Assistant Art Director
Suzanne Montgomery .... Editorial Assistant
Sally Fosnight .... Editorial Assistant

BUREAUS

LOS ANGELES ..... 9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks .... Bureau Chief
NEW YORK .... 20 East 46th Street
Michael Getler
CAPE KENNEDY .... 507 Orange Ave.
Merritt Is., Fla.
MIDWEST .... 423 N. Quentin
John L. Zimmerman .... Wichita, Kan.
PARIS .... 11 Rue Condorcet
Jean-Marie Riche
GENEVA .... 10 Rue Grenus
Frank G. McGuire

EDITORIAL ADVISORY BOARD

Dr. Peter Castruccio
Conrad H. Hoeppner
Alexander Satin
Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton .... National Sales Manager
Paul B. Kinney .... Eastern Advertising Manager
Edwin J. Denker, Jr. ..... Western Advertising Manager
Kenneth C. Blanchard. Marketing & Research Director
John N. Carlin .... Director of Circulation
Paddy Nelson .... Circulation Promotion
R. Virgil Parker .... Director of Production
Barbara Wiener .... Advertising Services Manager

Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President .... **Wayne W. Parrish**
Senior Vice President .... **Louis C. James**
Vice President .... **Fred S. Hunter**

THE COVER

Highly magnified photo shows one plane of fluidic logic elements (actual size approx. 1⅛ in. sq.) from counter produced at Martin-Orlando. Planes are made with etched brass and stacked to form miniaturized fluidic components. M/R's Special Report on Fluidics begins on page 18.

➨ FEBRUARY 8 HEADLINES

Gemini Action Gives NASA $1 Billion in Incentives 8
AIAA Gets Confident Report on Solids Future 8
ABRES Program Yielding Valid Scaling Laws 10
Space Agency Approves New Gemini Re-Entry Method . 11
Saturn V Static Test Slippage Will Not Delay Launch ... 11
Congress Sympathetic to Solids Funds Restoration 12
Two Rangers Set for Launch in Next Two Months 12
Ames Asks Proposals on Mars Atmosphere Probe 13
Quantity Production of Carbide Whiskers now Possible . 13
NOL's Neuristor Seen as Electronics Boon 14

➨ SPECIAL REPORT: FLUIDICS

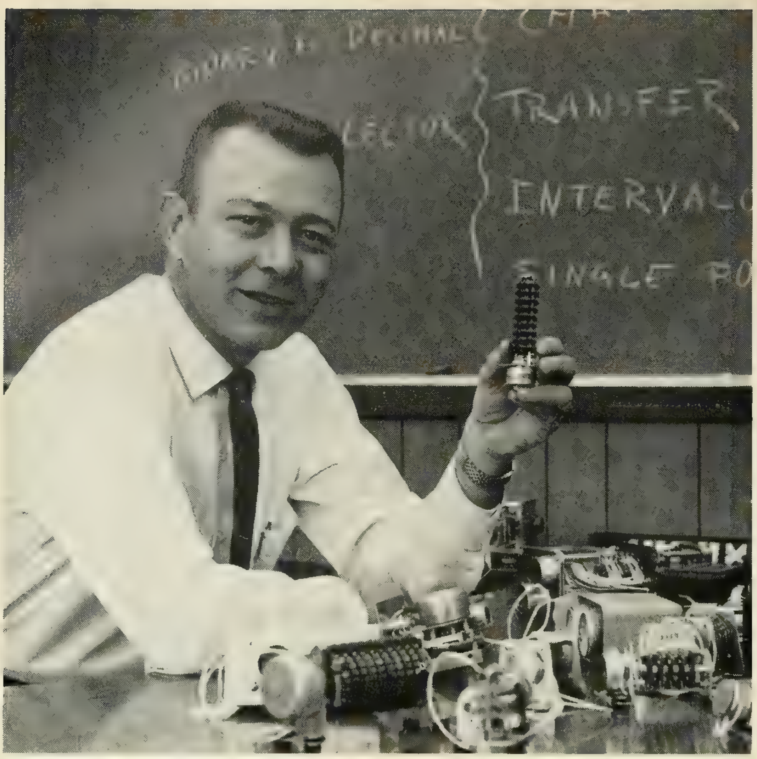
Compiled under the direction of Senior Editor Charles D. LaFond

Market of $250 Million Predicted by 1970 18
Technology Received Early Military Funding Support .. 30
A Summary of Trends Among Leading Organizations .. 36

➨ DEPARTMENTS

Letters 4
The Countdown 7
The Missile/Space Week® 8
Contracts/Procurements 52
When & Where 53
Editorial 54

49,200 copies this issue



This is a Ledex Stepping Switch.

It has many sizes and shapes.

It is called different things by different people.

You might put it in a black box and call it a programer, a transfer switch or a batch accumulator.

Somebody else might call it a light dimmer, sequencer or a binary-to-decimal converter.

For others this switch is a thermo-couple scanner, a figuregram (readout) controller, a memory pulse decoder, a destruct switch, a multi-pole double throw relay or a channel selector. For others it is an intervalometer, a mode selector or a coin counter.

This switch will be found in space, in the air, on the ground, and under water. Its economy puts it in commercial equipment; its reliability and miniature size put it in rockets. Its "hard" contacts are wiping and self cleaning. It does more work in less space.

It's ready to take on new, tougher assignments. Do you have one? Telephone 513-224-9891. TWX 513-944-0286.

Sincerely,

Gerald Leland
President

LEDEX

Ledex Inc.
123 Webster Street, Dayton, Ohio 45402

Circle No. 1 on Subscriber Service Card

letters

LMSC Infrared Testing

To the Editor:

Your article "Navy Sees Promise in Infrared Thermography for Solid Case Checking" (M/R, Jan. 4, p. 22) was accurate but not complete. I believe your readers would be interested to know that infrared nondestructive testing of *Polaris* rocket motors is more extensive than would be implied by use of thermographic data obtained by an infrared camera alone, and has been implemented with other instruments.

In addition, it should be remarked that the infrared nondestructive testing program the Navy is now pursuing for testing *Polaris* motors did not ". . . stem from associated tests the service has been running for the past six months . . . at the Naval Weapons Station, Concord, Calif." (quote from your article), although this is true as it relates to thermography.

The Lockheed Missiles and Space Company, in the Optics Department under the *Polaris* program, originated and developed the infrared nondestructive testing technique for *Polaris* motors, using a specially developed infrared scanner in a program extending over the past five years. The tests you mention at the Naval Weapons Station were an outgrowth of the Lockheed program. Infrared nondestructive testing systems designed and fabricated by the LMSC are now installed at the Naval Weapons Station, as well as at the Allegany Ballistics Laboratory, Cumberland, Md.

Having directed this program at Lockheed from its inception, and being aware of the extensive development necessary to realize a successful application of the technique in question, I feel that your readers should be better informed of this background.

Frederick E. Alzofon
Staff Scientist
Lockheed Missiles and Space Co.
Sunnyvale, Calif.

No-Steel Bethlehem

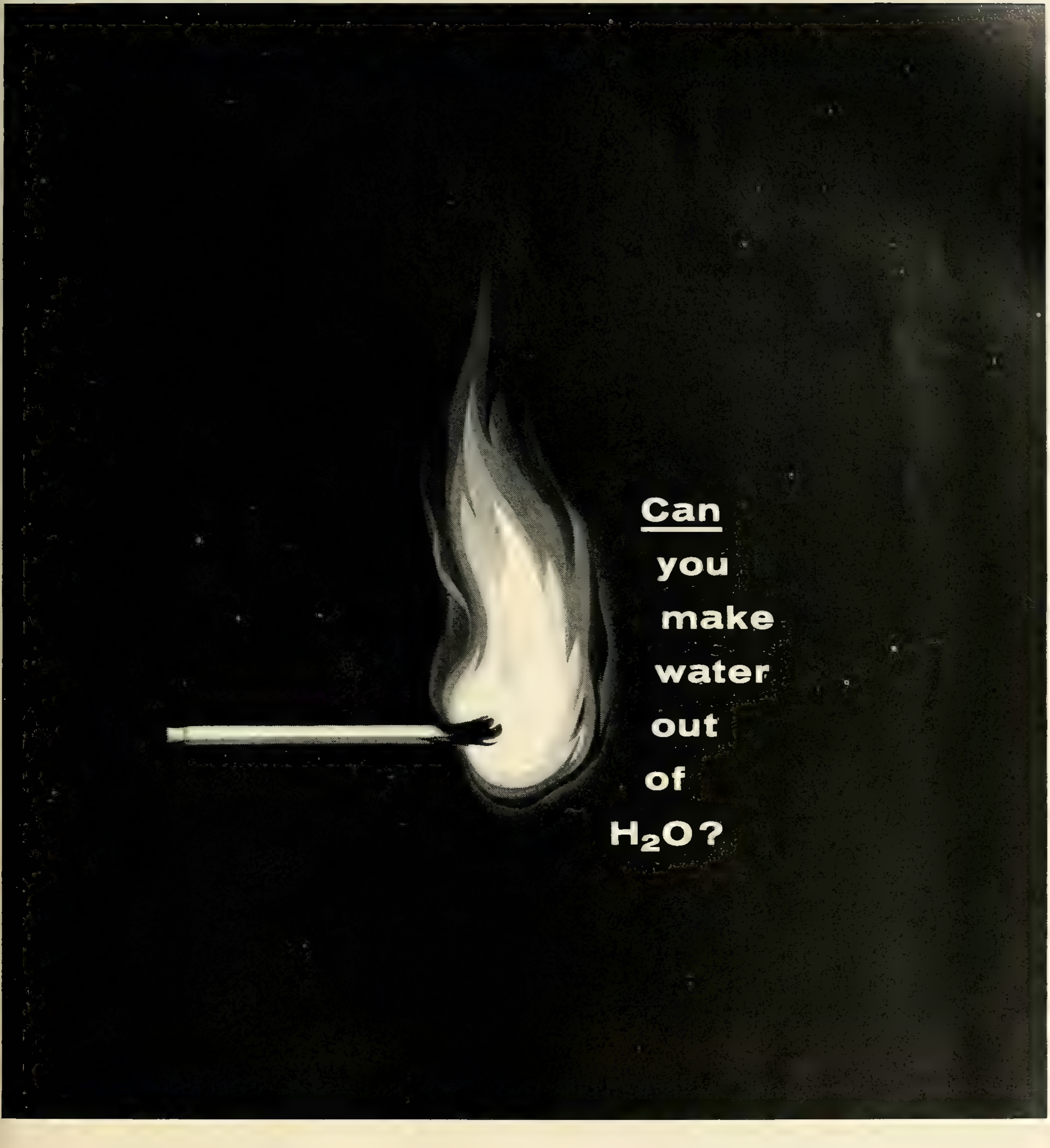
To the Editor:

We were pleased to see the article "Facility Tests Solids in Environmental Conditions" (M/R, Jan. 18, p. 31) concerning our new laboratory near Wayne, N.J.

On behalf of one of our valued suppliers, we would like to correct one item in the article. The 12-x-12-x-24-ft. Altitude-Temperature Chamber used by Associated Testing Laboratories, Inc., was built by The Bethlehem Corporation, 225 West 2nd Street, Bethlehem, Pa. This Bethlehem Corporation is in no way connected with the Bethlehem Steel Corporation, and we feel that credit for the chamber should be given to the proper party.

Robert Goldsmith
Vice President—Contracts
Engineering
Associated Testing Laboratories, Inc.
Wayne, N.J.

CAREER OPPORTUNITIES AT DOUGLAS



Two parts of hydrogen and one of oxygen leave a thirsty man high and dry. But give him a match to ignite the gases and a jar to catch and condense the steam, and he can drink the result.

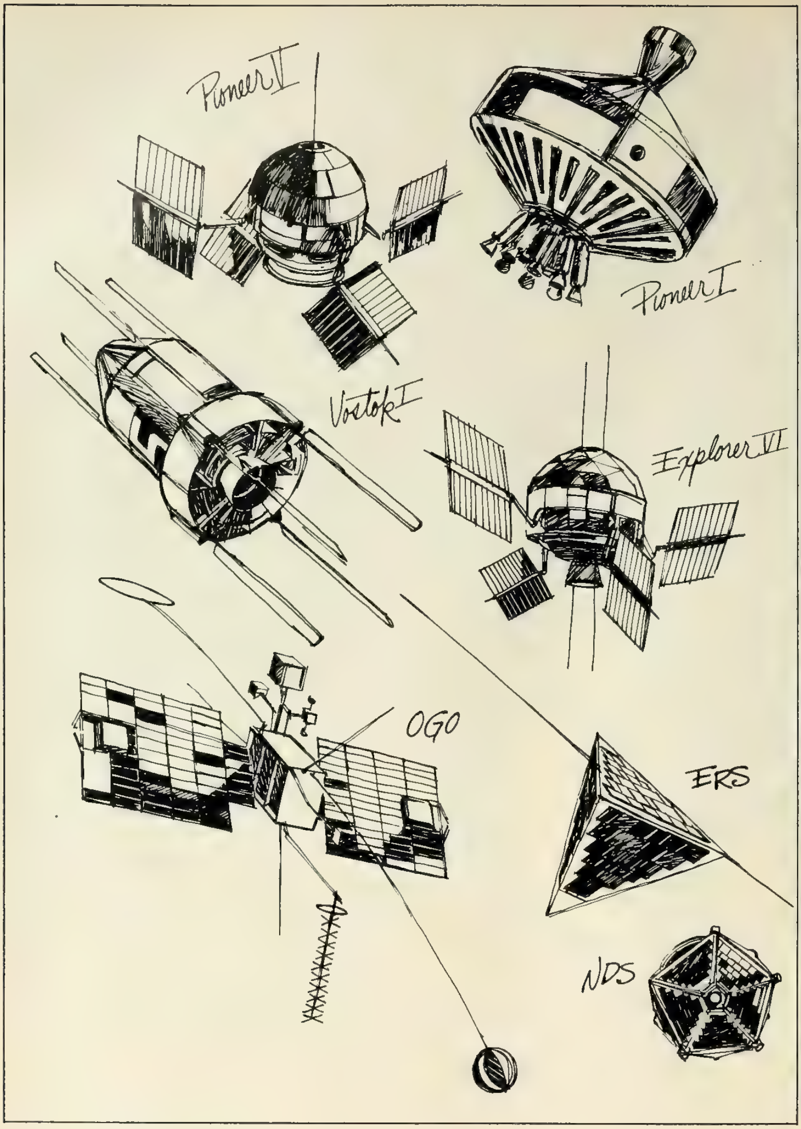
Likewise, capability in the individual sciences and skills involved in developing great aerospace and defense systems isn't enough. The right combining agency is essential.

That's where Douglas comes in. It has the ability to make big programs jell. And its comprehensive approach to technological achievements make it an ideal place for young engineers and scientists to grow in professional stature. At Douglas, you not only will have wide opportunities in your own discipline, but have every chance to integrate it with others as you contribute to the development of advanced space, defense and electronic systems.

If you would care to join us please send resume to Mr. G. A. Snodgrass at

DOUGLAS
MISSILE & SPACE SYSTEMS GROUP

An equal opportunity employer / **2700 Ocean Park Blvd., Santa Monica, California**



SOMEBODY ELSE BUILT THE VOSTOK

But TRW Space Technology Laboratories built all the rest. No other company has designed and built so many kinds of spacecraft for so many different space missions. Currently in production: Environmental Research Satellites, Nuclear Detection Satellites for Air Force-ARPA, and Orbiting Geophysical Observatory satellites and advanced Pioneer interplanetary spacecraft for NASA.

Today we are busy on many space projects that mean new opportunities for engineers and scientists. We are prime contractor for NASA's Orbiting Geophysical Observatory and Pioneer programs. We are developing the variable-thrust descent engines for Apollo and Surveyor lunar landings. And TRW Space Technology Laboratories continues Systems Management for the Air Force's Titan and Minuteman programs. These and other advanced space activities create opportunities in: Theoretical Physics, Systems Engineering, Radar Systems, Experimental Physics, Applied Mathematics, Space Communications, Space Physics, Antennas and Microwaves, Inertial Guidance, Analog Computers, Solid State Physics, Computer Design, Telecommunications, Digital Computers, Guidance and Navigation, Electromechanical Devices, Engineering Mechanics, Applied Aerodynamics and Propulsion Systems. For information about TRW opportunities in So. California and at Cape Kennedy, write TRW Professional Placement, One Space Park, Department MR2A, Redondo Beach, Calif. TRW is an equal opportunity employer.

Spacecraft above: Pioneer V, interplanetary probe, launched 1960; Pioneer I, lunar probe, launched 1958; Explorer VI, scientific satellite, launched 1959; ERS, environmental research satellite, launched 1962; NDS, nuclear detection satellite, launched 1963 and 1964; OGO I, orbiting geophysical observatory, launched 1964; Vostok I, manned Russian spacecraft, launched 1961.

TRW **SPACE TECHNOLOGY LABORATORIES**
THOMPSON RAMO WOOLDRIDGE INC.

655-A

The Countdown

WASHINGTON

Soviets Committed to Earth Orbit?

An Administration official disclosed that last week's reports of Soviet launch of a new space booster apparently refer to a launch vehicle in the *Saturn IB* or *Titan III* class. He said intelligence reports show no evidence that the Russians are building anything nearly as big as the U.S. *Saturn V*. This seems to indicate that the USSR is committed to Earth-orbit rendezvous for any manned flights to the Moon.

ABRES Input to START

The *Advanced Ballistic Re-entry Systems* program is having great impact on DOD's Space Technology and Reentry Test (START) program. Most of it, however, is concentrated at the working level. There's a lot of "cross-talk" between the Air Force's Ballistics Systems Div., *ABRES* manager, and Space Systems Div., START director. Within Aerospace Corp., which is participating in both programs, *ABRES* and START are being meshed.

Bomarc Shelf-Life Extended

Air Force has stretched the shelf-life of the *Bomarc B* booster from five to six years—at a savings of $2,100,000—by eliminating procurement of 51 additional units. AF Logistics Command now plans to further extend this expectancy to seven years.

Ranger Photos Indicate Lunar Rubble

Scientists analyzing pictures taken by *Ranger VII* now believe that the surface material in which it landed is composed of very fine rubble—perhaps as deep as 100 ft. Despite this, they feel that there will be no problems for the Lunar Excursion Module because of the many other smooth landing areas. Their final report is expected in about one month.

Poseidon Deadline Slips a Fortnight

Deadline for proposals for the propulsion units of the *Poseidon* missile has slipped to about Feb. 15. Previously, proposals were to be submitted Feb. 1. Five companies expected to bid on the first- and second-stage propulsion units include United Technology Center; Rocketdyne Div., NAA; Hercules Powder Co.; Thiokol Chemical Corp.; and Aerojet-General Corp. Lockheed Propulsion Co. is not expected to compete, since Lockheed Missiles & Space Co. is the integration contractor.

Sprint-Spoofing Penaids Sought

AF Ballistic Systems Div. is looking for a contractor to develop radar-reflecting penetration aids that will be able to pierce deep into the atmosphere. This type of penaid could be used to confuse *Nike-X* radars which use atmospheric sorting to determine the true warhead before launching the anti-ICBM *Sprint* missile. Program calls for development and flight test.

National Oceanographic Council Proposed

A bill to put oceanography on a par with space by setting up a National Oceanographic Council, corresponding to the National Space Council, has been introduced by Sen. Warren G. Magnuson (D-Wash.), who also happens to be chairman of the Senate subcommittee that handles NASA appropriations. Like the Space Council, the new group would have the Vice President as its chairman and draw members from the Cabinet. The bill also calls for the writing of an Oceanographic Act, similar to the Space Act. Present head of the Administration's oceanographic staff is Frank Di Luzio, former technical staff chief of the Senate Space Committee.

Hearth Heading Voyager Mars Program

Donald P. Hearth has been named manager of the *Voyager* Mars spacecraft program, which has an estimated cost of $1 billion. He previously served as director of Advanced Lunar and Planetary Programs in the Office of Space Sciences and Applications. Before joining the space agency, he was research project engineer of advanced propulsion systems at Marquardt Corp., directing that firm's early research into hypersonic ramjets and similar powerplants.

One-Man Lifting Body Re-entry Vehicle Planned

Bids are due at NASA's Flight Research Center on a preliminary feasibility study for a manned lifting body reentry vehicle. Two separate contracts are expected to be awarded by April 30. Study mission calls for one-man capacity and capability to make an orbital flight and land on a dry lake bed near Edwards AFB, Calif.

Army Looks at Urban Shelter Siting

Studies of the economics and location requirements for urban civil defense shelters are being requested by the Army. Shelters would be for either fallout only or fallout plus blast and fire. Able to withstand overpressures of 50 psi, they are to be sited under or in city parks, streets, schoolyards, basements and sub-basements of new buildings.

INDUSTRY

Pan Am Confirms Eastern Test Range Layoffs

Officials of Pan American World Airways' Guided Missiles Range Div. have confirmed that some 300 persons will be laid off from Eastern Test Range operations during the next two to three months. The division operates the range under Air Force contract. Some 150-170 of those laid off will be Pan Am personnel, the rest employees of RCA. Areas affected include the technical lab at Patrick AFB, Cape Kennedy itself, and the downrange sites of Malabar, Valkaria and San Salvador. The latter island was to have functioned at a reduced level this year, but instead will soon be put on standby status, say company officials. Total Pan Am/RCA employment at ETR is now approximately 10,400. The layoffs would mean a $2,400,000 payroll cut.

INTERNATIONAL

Hawker Siddeley, TRW Swapping Space Data

Hawker Siddeley Dynamics, Ltd., Harfield, England, and TRW Space Technology Laboratories have agreed to exchange technical information on spacecraft. STL will provide support to HSD in its role in the European national and international space programs. HSD was responsible for developing the *Blue Streak* launch vehicle.

SIDE-LOOKING RADAR SYSTEMS ANALYSTS

New programs at HUGHES are generating opportunities for Systems Analysts experienced in high-resolution data gathering, data transfer and data processing systems. Openings exist for Systems Engineers, Mathematicians and Physicists qualified in synthetic array radars, optical, and other data collection systems (IR, Electro-Optical, SIGINT and others). Assignments include:

Senior Systems Scientist with 20 years' electronic systems experience—at least 10 years relevant to side-looking radar systems. Applicants will be considered for important program management responsibilities. M. S. or Ph. D. degree required.

Senior Systems Analysts with 10 years' electronic systems experience—at least 5 years relevant to high-resolution systems pre-design and evaluation. Applicants will be considered for assignments in concept formulation; single and multi-sensor applications; data transmission, processing and interpretation; systems integration and performance evaluation. M. S. or Ph. D. required.

Systems Analysts with 5 years' experience in: detection of signals in noise, optimum filter theory, nonlinear signal processing, information theory, MTI and doppler systems analysis. B. S. or M. S. required.

Please airmail your resume to:

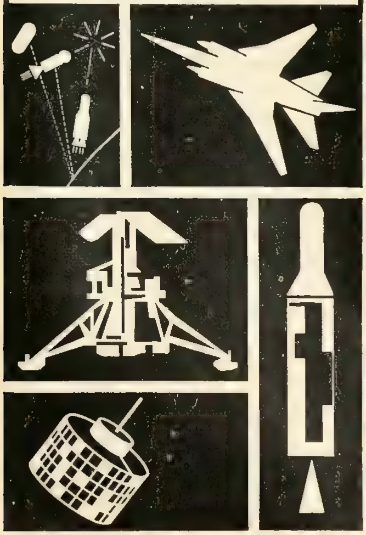
MR. ROBERT A. MARTIN
Head of Employment
Hughes Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 18, California

Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS

U. S. CITIZENSHIP REQUIRED
An equal opportunity employer.



The Missile/Space Week

Shots of the Week

NASA launched its second *Orbiting Solar Observatory* satellite Feb. 3 from Cape Kennedy and within hours was receiving data from several of the experiments on board.

First to be turned on was the emissivity measurement contributed by Ames Research Center. It was followed in order by experiments furnished by the University of New Mexico (high energy gamma ray measurement), Goddard Space Flight Center (gamma ray experiment), Naval Research Laboratory (two experiments), Harvard University (ultraviolet spectometer), the University of Minnesota (zodiacal light device), and Goddard (ultraviolet spectrophotometer).

The 545-lb. satellite was set in orbit close to the nominal 345-mi.-high circular path by a *Delta* vehicle. Initial orbital information disclosed by Goddard Space Flight Center was: apogee, 393 mi.; perigee 343 mi.; period, 97 minutes; and inclination to the equator of 33 degrees.

- The Navy on Jan. 26 fired a *Hyda-Iris* sea-launched rocket to 184 miles altitude carrying with it a 100-lb. payload. The rocket was launched from a point about 1,400 miles east of Montevideo, Uruguay. Mission was to measure radiation intensity within the inner Van Allen radiation belt.
- The fourth stage of a *Blue Scout* rocket launched by the Air Force on Jan. 28 from Cape Kennedy failed to ignite, permitting its instrument payload to crash into the South Atlantic south of Ascension Island. A signal intended to trigger destruction of the stage failed, but it disintegrated on its own.
- Army troops from Ft. Sill, Okla., on Jan. 28 successfully launched a *Pershing* tactical missile from Ft. Wingate, N.M. The warhead impacted as planned 200 miles away within the White Sands Missile Range. More firings are planned in the course of training exercises being conducted at Ft. Wingate.
- The Soviet Union has launched a "new type" space booster that spanned more than 8,000 mi. of the Pacific, according to the official news agency Tass. The firing, conducted Jan. 30, was said to have been so successful that a second planned shot was cancelled.
- Japan on Jan. 31 launched *Lambda III-2*, the largest rocket that country has yet developed. The 62-ft., three-stage rocket attained an altitude of 620 mi. and impacted northwest of the Mariana Islands, some 1,130 mi. from the launch site at Tokyo University's space center on Kyushu.

Phoebus Nozzle Sought

NASA is negotiating a two-phase contract with an estimated value of $10.4 million with Aerojet-General Corp. for design and development of a liquid-hydrogen, regeneratively cooled exhaust nozzle for the *Phoebus* nuclear rocket reactor test program.

Phoebus is a 5,000-megawatt reactor that will be tested as part of the U.S. program to develop nuclear rockets for space missions. The first phase of the contract calls for a four-month preliminary design study of nozzle concepts and an evaluation of fabrication and testing methods. This phase will be negotiated on a cost-plus-fixed-fee basis at an estimated value of $400,000.

Gemini Contract Changed

NASA has converted its $712-million *Gemini* spacecraft contract with McDonnell Aircraft Corp. from a cost-plus-fixed-fee to a cost-plus-incentive-fee. The contract—the largest incentive contract that NASA has negotiated—brings the total of such awards to over $1 billion.

The contract provides profit incentives for outstanding performance, control of costs, and timely delivery as well as potential profit reductions when performance, cost, and schedule requirements are not met.

Solids Progress Predicted

Prospects are good for significant future progress in the solid propellant field, Lt. Gen. W. A. Davis, vice commander of the Air Force Systems Command told the sixth annual Solid Propellant Conference of the AIAA.

Among the advances foreseen by Project Forecast, Davis said, were: a 10% increase in deliverable specific impulse in this decade, consequent payload increases of 60% and an increase in burning rate by a factor of 10 without sacrifice in specific impulse or density.

Having demonstrated in the first phase of the 156-in. solid program low-acceleration, long-burn-time characteristics for strap-on application to present boosters, the emphasis in the 156-in. program has shifted to demonstration of characteristics for tandem boosters. Among these are higher acceleration, faster burning motors of shorter lengths.

Air Force studies of 156-in. strap-ons for the *Titan III-C* show that the space booster's payload can be boosted 60% to more than 40,000 lbs. in orbit.

GAO Charges Nimbus Error

Alleged mismanagement of the *Nimbus* meteorological satellite project resulted in unnecessary costs amounting to $1.2 million, the General Accounting Office has charged.

NASA's project manager at Goddard Space Flight Center "did not effectively carry out his responsibility" for project planning when it became evident that weight design goals established for the *Nimbus* spacecraft had become obsolete, it was charged.

The auditors said that in March, 1961, shortly after the award of a cost-type contract to General Electric Co. for the design, integration and test of the spacecraft, information available to the *Nimbus* project manager showed that the estimated satellite weight of 692 lbs. exceeded the design weight of 650 lbs. which, in turn, exceeds the reported 580-lb. capability of the launch vehicle to be used in the program. Two months later, when the final official allowable spacecraft weights were provided by the Launch Vehicle System Manager, GAO went on, "available information showed that the spacecraft's estimated weight had increased to 726 lbs. while the launch vehicle's reported capability at the planned orbital altitude had decreased to 567 lbs."

The GAO review disclosed that during the next five and a half months, the *Nimbus* project manager allowed GE to continue working toward the original design goal of 650 lbs. "even though it was clear (the effort) would be futile" because of booster limitations.

Cape Strikers Back at Work

Striking construction workers from 18 unions returned to work on 45 different Cape Kennedy area projects Feb. 1 after receiving assurance of a Feb. 9 hearing of grievances before the President's Missile Sites Labor Commission.

The three-day strike by 3,800 men stopped work on some $200 million worth of construction. The walkout was in protest against the wage scale paid by one contractor.

Vitreous Silica Fabric Marketed

J. P. Stevens & Co. is increasing its suppliers' share of the missile/space market with the introduction of a high-temperature vitreous silica fabric called Astrosil.

Details of the manufacturing process were not disclosed except that the glass fabric is chemically purified with acid and heat to withstand 2,000°F temperatures.

While the missile and space market remains the largest customer for silica glass fabrics, Irwin J. Gusman, manager of the Industrial Glass Fabrics Div., says Stevens plans to explore other areas such as lubrication in the extrusion of high alloy steels, ceramic reinforcing, ion exchange mediums and molten metal filtration.

NAA Gets $61.1M More for S-II

NASA's Marshall Space Flight Center has made a $61.1-million modification to its contract with North American Aviation's Space & Information Systems Div. for production of the *Saturn V* S-II second stage.

The additional money covers six sets of ground support equipment, including automatic checkout, servicing, handling and auxiliary equipment.

The original contract, awarded in October, 1962, called for delivery of 10 of the S-II flight stages, a facility checkout model, dynamic test vehicle, "battleship" static-test stage and all-systems test model. The modification brings the total value of the NAA S-II contract to $413.5 million.

FCC Bars Comsat Pact

The Federal Communications Commission has blocked, at least temporarily, a Communications Satellite Corp. plan to award a letter contract to Hughes Aircraft Co. (M/R, Feb. 1, p. 8).

The $100,000 award was to be a step toward procurement of 24 synchronous-orbit satellites which Comsat hopes to furnish the Dept. of Defense for use in the initial defense satellite communications project.

The FCC ruled Feb. 3 that the corporation was defective in the filing of its statement of intent last month because the contracting method was sole-source. Comsat must meet with all interested parties and hear their qualifications before making such an award, the FCC ruled.

space station

One Space station is at Brown Engineering Company, located in Huntsville, Alabama, Space Capital of the Nation, where the sights are on the stars. Join Brown and do the never-done while participating in the conquest of space with an established support contractor to the Marshall Flight Center on the Saturn Launch Vehicle Program.

Immediate Openings

available for qualified men in the following job classifications:

- Liquid Rocket Propulsion Engineers
- Thermodynamics and Fluid Mechanics (Analytical) Engineers
- Research Engineers of Physicists in areas of rocket acoustics, unsteady aerodynamics theory and ground-wind induced oscillations.
- Aerodynamics/Structural Dynamic Engineers to analyze fin and panel flutter problems on space vehicles.
- Structural and Stress Engineers
- Static and Dynamic Loads Analysts
- Vibration and Acoustic Engineers
- System Integration Engineers
- Systems Test and Checkout Requirement Engineers
- Launch Vehicle Specification Engineers
- Vehicle Interface Compatibility Analysts
- Reliability Engineers
- Mechanical Designers
- Standards Engineer
- Mission Analysis Engineer
- Ground Support Equipment Engineer with Launch Vehicle Experience
- Hydraulic Pneumatic Test Engineers

BE WITH THE MEN WHO ARE THERE: Join them, the imagineers, the 3,000 strong there at one of the leading aerospace engineering organizations in the country. Be with the men who are there, there at Brown in Huntsville. Here are top working conditions, living conditions, growing conditions. Go with Brown. Grow with Brown.

Submit Your Resume in Confidence to: William A. Giardini, Vice President and Manager of the Space Vehicle Division.

BROWN

ENGINEERING COMPANY, INC.
300 Sparkman Drive, N.W.
Huntsville, Alabama 35807
An Equal Opportunity Employer

Circle No. 2 on Subscriber Service Card

Boon to re-entry design . . .

Scaling Laws Set by ABRES Program

Full-scale tests of missile re-entry vehicles will still be needed, but sub-scale lab or flight tests are now possible

by James Trainor

ONE OF THE MAJOR objectives of the *Advanced Ballistic Re-entry Systems* (*ABRES*) program—development of scaling laws for missile re-entry vehicles—has been achieved. Defense officials say they have now reached a point "where we understand what we see and can predict what we haven't seen."

However important this advance may be, it still does not alleviate the necessity for some full-scale re-entry vehicle testing. These officials say the scaling laws "don't satisfy in every aspect," and the physical phenomena are so complex that "we almost have to go full-scale to normalize" the data.

Nevertheless, scaling laws are giving a greater degree of confidence to re-entry system designers. They also make possible sub-scale testing in laboratories or on relatively inexpensive boosters, such as *Athena,* before making a commitment to a full-scale flight test.

This is only one objective of the national program on re-entry systems. In the language of DOD, *ABRES* is an advanced development program whose purpose is to make available "advanced front ends" for ICBM's. As such, it precedes any operational requirement and provides the base upon which an engineering development can be based.

In existence since 1962, *ABRES* has already had an effect on re-entry vehicles now under development. "I can cite several examples of fallout from *ABRES* that are now in operational development," one DOD official says.

Specifically, he singled out the Mark 12 re-entry system now being developed for the *Minuteman II* by General Electric. "There are a number of things in the Mark 12 that we couldn't have done without *ABRES.*"

- **Here to stay**—Inasmuch as *ABRES* is aimed toward the twin goals of ensured penetrability and increased warhead effectiveness on target, the program has evolved into a continuing scientific and engineering effort and is expected to be funded at a sustaining level in the future. In this, it resembles ARPA's Project Defender, which annually receives about $100 million and is designed to investigate advanced anti-missile system concepts.

From its inception through the current fiscal year, *ABRES* has had total funding of $400 million. However, this does not include all the advanced re-entry work, since a large chunk of this is funded under operational system developments.

Furthermore, the funding figure is misleading because of the extremely high "price of admission." Approximately half of the funds are spent on supporting efforts, such as the launch vehicle, launch services, data processing, instrumentation, and management. Of the remaining one-half, the money is approximately divided equally between increased penetrability and increased destructiveness.

Illustrative of the costs ancillary to the re-entry system itself is the launch vehicle cost. Since the *Atlas* is the primary booster for full-scale tests, the booster cost is approximately $1.5 million per flight. With the *Athena,* the cost drops dramatically—to substantially less than $500,000 per flight, with an end objective of $350,000 per test.

To reduce supporting costs, the *ABRES* program has been shifted entirely to the Western Test Range. There the launches are conducted by the same crew which fires the *Nike* target vehicles. The *Athena* program is concentrated at White Sands Missile Range, N.M., with the test vehicles being fired into the range from Green River, Utah.

- **Atlas and Athena**—The phasing out of the operational *Atlas* missiles—particularly the *F* models—has given the *ABRES* program a surfeit of missiles. In fact, there are now boosters enough to last for "many years," according to a Defense official.

The *Atlas F* is particularly suited to the *ABRES* program because it is not payload-limited for the missions. Also, it is advantageous from a range safety standpoint.

In order to benefit both the *ABRES* and the *Nike* programs, the boosters are fired so that the re-entry vehicle will be "seen" by either the Tradex radar on Roi Namur or the *Nike* radars on Kwajalein—and in most cases by both.

The same advantage accrues to both programs when *Athena* payloads are fired into White Sands. The range is heavy with *Nike* equipment, including the Multi-Array Radar, and is also honeycombed with optical and other instrumentation.

Single decoys and small sub-scale re-entry models are *Athena* payloads. Flights of the 77-vehicle program began early in 1964 and were plagued with problems. Now, however, the program "has matured and is now one of which we can be proud," reports a DOD official. Stressing that this is an economical way of gathering data, he reiterated DOD's intention to carry through the full program.

ABRES is managed by the Air Force's Ballistic System Division as a national program. Included on the *ABRES* program staff is a Navy captain, assigned full-time, as Deputy for Navy Applications. An Army officer, specifically responsible for *Nike* target vehicles, provides a liaison between *ABRES* and Army interests in the program.

First flights of the *ABRES* program have been completed. These were three Re-entry Experiment (REX) vehicles built by Chrysler Corp. for the Air Force. They were "highly successful," according to Defense officials.

Upcoming are flights of two maneuverable re-entry vehicles. One is under development by McDonnell Aircraft Co. and is known as A-Ball (for Aeroballistic re-entry). The second is the General Electric Maneuvering Ballistic Re-entry vehicle.

GE's vehicle will be tested first; the McDonnell entry will follow later. There are no plans to incorporate either into the operational inventory. Like REX, they will contribute to the reservoir of technical knowledge to meet future requirements. ■

Backing up retros . . .

Gemini May Use New Re-entry Mode

Orbital Altitude Maneuvering System would be fired to lower apogee; directors drop plans to roll spacecraft during landing

A NEW TECHNIQUE for *Gemini* re-entry is being considered by the *Gemini* Program Office at NASA's Manned Spacecraft Center in Houston.

Charles Mathews, program manager, said the procedure would use the spacecraft's Orbital Altitude Maneuvering System (OAMS) to "back up the retro-rockets."

The OAMS would be fired in retrograde at a perigee of 87 n. mi., to lower the spacecraft apogee to approximately 47 n. mi.; this would be followed immediately by retro-rocket firing. If approved, the system would be used during the upcoming *Gemini/Titan II GT-3* mission, when two astronauts will orbit the Earth three times.

The *Gemini* Project Office also is considering operating at a lower apogee altitude—about 141 n. mi.—because the lower altitudes offer "greater heat protection" prior to re-entry. Mathews said, however, that orbital altitudes will be "custom-tailored for each mission."

MSC officials expect to launch the *GT-3* spacecraft in the first two weeks of April.

The target date now is the last week in March, but MSC sources believe the first two weeks of April is a more realistic forecast.

- **No landing roll**—Astronaut Thomas P. Stafford said flight directors have abandoned the plan to roll the *Gemini* spacecraft during landing as a method of slowing the roll rate to control the landing footprint. Stafford, who is part of the back-up pilot team, said in an interview that astronaut Virgil "Gus" Grissom will hold the craft in a 60° left bank, with air pressure throwing the craft into the target area.

This should permit the spacecraft to land within 10 mi. of the target, he said.

Plans also call for astronauts to attempt communications through the ionization layers 16 minutes after retro fire. The co-pilot will trigger a flow of distilled water by releasing a compressed nitrogen spray beneath the spacecraft. It is hoped that this will enable successful communication with ground stations.

At the end of the first orbit, an attempt will be made to change the apogee height from 160 mi. to 130 mi. The maneuver will take place as the spacecraft passes over Mexico. Near the end of the second orbit, the perigee will then be lowered from 87 mi. to the desired 47-mi. altitude prior to re-entry.

- **Crewing up**—It was also learned that MSC expects to announce the crew shortly for *GT-5*, slated to be a record-breaking seven-day flight. Among the flight-ready astronauts, only Maj. Gordon Cooper, Lt. Charles Conrad, Neil A. Armstrong and Elliott M. See are not committed to a flight. The *GT-5* capsule is nearing the systems-test stage and a crew is needed to see it through to flight stage.

Astronaut Walter Schirra believes he is a good possibility to be selected as pilot for *GT-6*, the first *Agena* rendezvous flight. He said a third computer will be added to simulators at Cape Kennedy and MSC to give pilots an "out-the-window" imitation of the rendezvous with the rocket.

An early data report from the Jan. 19 unmanned *Gemini* indicates that heating in the adapter section was higher than expected. Officials believe it will have to be striped with paint or tape for better heat rejection in order to make the space radiator function properly. ■

Saturn V First Stage Test Due June 1

MARSHALL SPACE Flight Center officials report that the first static test of the *Saturn V* first stage will be made about June 1, 1965—some six months behind the previous schedule calling for a "hot" test in the last quarter of 1964.

Official spokesman at NASA headquarters said, however, that they still believe the giant 7.5-million-lb.-thrust stage will be ready for its first launch early in 1967.

The current plan is to mount the first static-test stage in the firing stand in a couple of months. The first firing of a single F-1 engine will be attempted approximately June 1. After three weeks, a three-engine firing will be held; a full five-engine firing is to follow in another three weeks.

Test firing of the static stage is scheduled to be completed shortly after the end of 1965, NASA officials said. Then the first S-IC flight stage is due to be mounted on the stand for a test run of about six months. It will be moved to Cape Kennedy in the last half of 1966.

- **Taking up slack**—Officials blamed the slippage in the static test on Congressional budget cuts. Apparently they hope to make up the lost time in the development program by telescoping some of the later planned static-test work.

Parts for the 138-ft.-long, 33-ft.-dia. test stage were manufactured at the Boeing Co. facilities in Wichita, and at the NASA Michoud Operations in New Orleans.

The big vehicle will be hauled from the MSFC manufacturing area to the test stand next month, aboard a unique "transporter" on which it was assembled. The hauler's wheels are five feet tall and have a 20-in. tread.

Weight of the stage is about 280,000 lbs.

When fully fueled on the test stand, the stage's two propellant tanks will contain about 4,400,000 lbs. of liquid oxygen and kerosene.

If NASA is persuasive . . .

Congress May Restore Solids Funds

Anderson indicates Senate Space Committee would be receptive to strong plea for both big solids program and M-1 engine

by Heather M. David

SENATE SPACE COMMITTEE Chairman Clinton P. Anderson (D-N.M.) has put NASA on notice that funds for the solid-propellant booster program and the M-1 engine could be forthcoming if the agency makes a good case for them during the authorization hearings.

At the same time, the Space Committee disclosed that the *Titan III-X/Agena* has become a member of the standard launch vehicle family with the concurrence of the Dept. of Defense and NASA. Also, it was revealed that DOD has dropped plans for a high-energy upper stage based on the opinion that *Centaur* is adaptable to *Titan III-X* and *-C* missions.

Cancellation of the solids and M-1 programs, which were deleted from the FY '66 budget for economy reasons, has stirred considerable furor in Congress.

Sen. Richard Russell (D-Ga.) chairman of the Senate Armed Services Committee and Defense Appropriations subcommittee, said that apart from the economic distress the cancellation of the solids project will create at Thiokol Chemical Corp.'s booster facility at Brunswick, Ga., he was concerned about its effect on the long-range space effort and on the security of the country.

"It will cut off, at a particularly inappropriate time," he declared, "a crucial research and development program that already has shown significant potential for fulfilling future space booster needs—for both defense and non-defense purposes."

Anderson has indicated that the Space Committee stands willing to hear a plea for both the solid-propellant program and the M-1 engine. NASA Administrator James E. Webb himself forecast such a request last week in hearings before the committee.

He characterized the three efforts—solid-propellant boosters, M-1 engine and the SNAP 8 nuclear reactor—as being the ones with "the most apparent promise for application in the future, and which provide the greatest assurance for availability in a reasonable time period." Under questioning, it is reported, he said that budgetary reasons alone forced the cancellation of these programs. Then, as if to make his point clear, he said "a policy of support for the development of carefully selected advanced propulsion systems must be followed if we are to assure that they will be available when needed."

- **DOD actions**—Clarification of Dept. of Defense plans for the *Titan III* was made during the two-day booster hearings.

Assistant Air Force Secretary (R&D) Alexander H. Flax said that DOD has dropped any plans for a high-energy upper stage, on the basis of careful assessment of the *Centuar* stage. *Centaur* can be adapted to *Titan III-X* and *Titan III-C*, and "such combination will offer economical and effective launch capabilities for both DOD and NASA missions," he said.

Flax also disclosed a program for increasing the capacity of satellites to perform evasive maneuvers. The program would be directed at *Titan III-X/Agena* payloads, to size and define performance requirements of the propulsion systems. Secondary consideration would go to *Titan III-C* payloads, Flax said.

- **Titan III stretchout**—The 17-vehicle test program of the *Titan III* has been stretched out by one year to preserve a logical phase-in to the *Manned Orbiting Laboratory* (*MOL*) flight program and other potential users such as the follow-on communications satellite program.

Deputy Secretary of Defense Cyrus Vance said that 11 experimental payloads besides the three defense communications satellite deployment flights have been assigned to seven other vehicles.

In general terms, the tone of the hearings was that no changes need now be made in the launch-vehicle programs of the DOD and NASA for missions through the next 10 years. For this time period, difference in costs for the available boosters is less than 1%, the Aeronautics and Astronautics Coordinating Board determined. ■

Two Rangers To Probe Dark Maria

The eighth and ninth spacecraft in the *Ranger* series will be launched in the next two months in an attempt to obtain pictures of the lunar surface near the Moon's terminator.

The launch window for the next flight opens Feb. 17 and it will last seven days. NASA scientists hope to photograph one of the darker maria, or seas, which are free of crater rays. If successful, the spacecraft will be named *Ranger VIII*.

The last shot in the lunar hard-landing series will be launched approximately 30 days after the February launch window. Its landing area will be selected after results of *Ranger VIII* are known.

Ranger VII, which returned 4,316 high-resolution pictures before it impacted on the Moon July 31, 1964, photographed a bright mare named Mare Cognitum, which is streaked with rays of material splashed from the lunar surface when the large crater Tyche was formed.

Examples of darker maria toward which the next *Ranger* spacecraft will be headed are Mare Tranquillitatis and Mare Vaporium, which are accessible during the first two days of the launch period.

To take pictures of the dark areas, the sensitivity to light of the three cameras with f/2 apertures has been increased. This has been accomplished by increasing the amplification of the video signal from the three cameras.

Three other cameras with larger f/1 apertures will not be changed.

To lessen Voyager risk . . .

Mars Atmosphere Probe Proposed

Ames Research Center has requested proposals on a 25-lb. vehicle to obtain density and composition data in 1969

by Robert Lindsey

MOFFETT FIELD, CALIF.—Scientists here are urging a 1969 probe to define the Martian atmosphere before efforts are made to land a life-detection capsule on Mars in NASA's Project *Voyager*.

Without the probe, the Mars-landing portion of *Voyager* will be a "high risk" effort, in the view of Alvin Seiff, chief of NASA's Ames Research Center Vehicle Environment Branch and a renowned authority on re-entry problems.

Seiff proposes launching a spherical 25-lb. probe into the Martian atmosphere to define its density and composition as a preliminary step to landing of the *Voyager* life-detection capsule.

As now conceived, *Voyager* includes tentative plans for a 1969 orbit of Mars by the *Voyager* "bus" and a 1971 effort to land the life-detection system.

- **Study RFP's out**—Inclusion of the *Mars Atmosphere Probe* (*MAP*) in the *Voyager* program is under consideration by NASA headquarters, which has backed the studies here. But at this time it is not a part of the *Voyager* concept.

Ames has requested proposals from industry for a study to define *MAP*. Proposals are due March 15.

Seiff said the *MAP* could be launched either from the orbiting *Voyager* bus or on a direct flight by an *Atlas-Agena*. Detailed cost estimates have not been made, but he said that even if it was conducted as a preliminary step to *Voyager* the *MAP* would be a bargain compared with the total cost of *Voyager* "and the chances of (*Voyager*) success would be greatly improved."

Urging a "logical, sequential approach" to Mars exploration, Seiff indicated he is critical of a tendency in some quarters to go ahead with major elements of *Voyager* without first determining the nature of the atmosphere.

Although achieving *Voyager* goals without the *MAP* is possible, he declared, this would require contingencies for a wide band of uncertainty about the atmosphere—and perhaps superfluous systems to permit the soft landing. Or perhaps, he said, the uncertainty could cause miscalculations that would hurl the lander into the planet's surface with too much force.

- **Getting answers**—There has been much speculation about the Martian atmosphere, he said, but "regardless of what you've heard, the atmosphere is absolutely unknown . . . and until we can define it I don't believe we should attempt any of the more sophisticated programs."

He noted that authoritative scientists have made estimates of Mars' surface pressure ranging from 10 to 130 millibars (a millibar is equal to 1/1,000th of Earth's sea-level pressure). Thus, these estimates range from the equivalent of 1 to 13% of one Earth atmosphere.

Besides providing data engineers could use in developing the braking system for the *Voyager* lander, Seiff said the *MAP* could get qualitative information on the Martian atmosphere which life scientists could use in planning the *Voyager* life-detection system.

- **Concept**—Two feet wide, the *MAP* is envisioned as a low-density structure of six pounds per cubic foot, about half the density of cork.

Instrumentation would include accelerometers to sense the braking effects of the atmosphere and a detector-filter spectrometer system behind a window. As the probe entered the atmosphere, the radiation from the hot-gas cap at the nose would be examined by the spectrometer system to identify the gases in the atmosphere.

A relay vehicle would be necessary to return the data to Earth, regardless of whether the *MAP* was launched by *Atlas-Agena* or the *Voyager* bus.

In the latter case, the orbiting bus would serve as the relay, while a fly-by vehicle might act as a relay for the direct approach method.

Seiff said considerable basic work is under way at Ames to learn problems of the *MAP* mission, and the upcoming industry study will further refine the question. He said there is adequate time to plan for the 1969 Mars opportunity, although not the 1966 window. Design of the probe, he said, is expected to be a rather straight-forward operation, using the present state of the art. ■

Carbide Whisker Production Boosted

SINGLE-CRYSTAL silicone carbide whiskers can now be commercially produced in substantial quantities at The Carborundum Co. Pilot manufacturing facilities are in operation and no problems are seen in scaling up to whatever capacity is warranted by demand.

The proprietary carbide single-crystal process was developed in the firm's Research and Development Div. The whiskers have tensile strengths of up to 3 million psi and elastic moduli of 70 million psi.

Silicone carbide will maintain its strength in air up to 3,180°F, and in inert atmospheres to at least 3,600°F. Because of its infrared opacity, the material possesses insulating potential at both temperature extremes—from —450°F to 3,600°F.

Whiskers of such materials long have been known to possess fantastic strengths—up to the theoretical limit. The problem, until now, has been to produce them in sufficient quantity to use as reinforcements in structures. But the Carborundum process makes silicone carbide whiskers a new contender in the reinforced plastics and metals fields.

First described in 1960 . . .

NOL Develops Nerve-Like Diode

Neuristor promises to bring as much change to electronics as transistors; could greatly reduce size of computers

by William S. Beller

WHITE OAK, MD.—Scientists at the Naval Ordnance Laboratory (NOL) have created an electronic device as simple and almost as small as a nerve fiber.

Like the nerve fiber or nerve axon, it does its job without transistors, resistors, capacitors or inductors. It can propagate signals without attenuation along its length.

This novel device is called a neuristor, an electronic element first described in late 1960 by Hewitt D. Crane of Stanford Research Institute but only recently fashioned into a practicable piece of hardware.

The name neuristor is derived from neutron and describes a "whole class of lines that exhibit attenuationless propagation with recovery," Crane wrote in the *Proceedings of the IRE* of October, 1962. Since that time, many investigators have tried to find a way to build such lines, but found that they were too complex to be useful.

● **Nerve-like neuristors**—An answer is probably at hand through the work of A. J. Cote, Jr., chief of NOL's Advanced Engineering Div., who has already demonstrated an electronic device showing propagation phenomena similar to those observed in the axons of nerve cells.

Using a unique tunnel diode made to Cote's specifications by RCA's Electronic Components and Devices unit at Somerville, N. J., it "appears to be of the type desired to realize the neuristor device proposed by H. D. Crane," Cote said in a letter in the current issue of the *Proceedings of the Institute of Electrical and Electronics Engineers (IEEE)*.

Neuristors, if further developed, could bring as much change to the electronics industry as has been wrought by transistors. They can be looked upon as channels with energy sources continuously available along their length. When a pulse is generated, it moves without attenuation down a channel just as a flame travels along a chemical fuse—or a nerve impulse along the axon of a nerve fiber.

The "active wire" of the chemical fuse can be used only once, but the axon and the neuristor "recover" and can be used for succeeding pulses after a short refractory period. For the axon, this period is several milliseconds; Cote has not yet accurately measured it for the tunnel-diode neuristor.

Neuristors have additional properties that lend themselves to logic circuits. No discrete electronic elements, such as resistors and capacitors, are needed for these circuits, since these elements are inherent and distributed in neuristors and neuristor circuits. How much smaller computers could be made if they were neuristorized is not yet clear, but an idea may be gained by observing that some test neuristors are only about five mils thick.

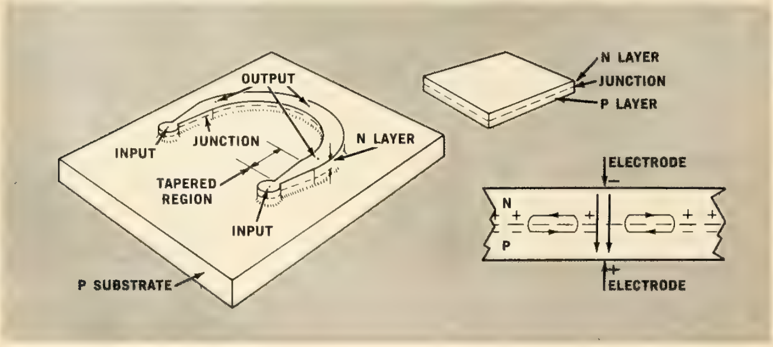
● **How axon works**—The axon of an adult human male is a narrow channel about one mil thick and sometimes several feet long.

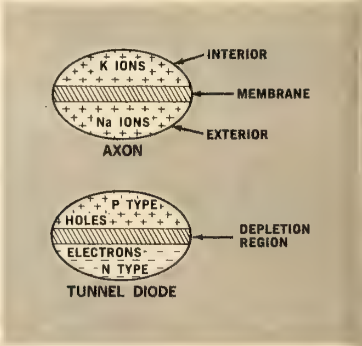
Within the human body, nerve axons are the cables that transmit signals in the form of impulses from cell body to cell body. Receptor cells generate the impulses, for instance, and send them through the axon to higher centers in the nervous system. The higher centers, in turn, relay their instructions or signals in terms of impulses along axons connected to the "working" cells, which may be muscle cells. In reflex reactions, the signals bypass the switching at the higher nervous center to go directly to the muscle cells.

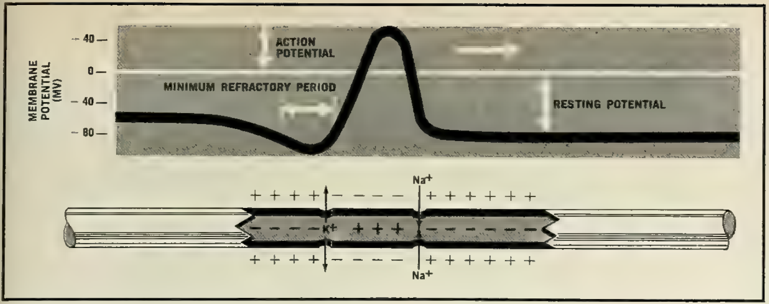
Propagation of nerve impulse along the axon provided the key to the tunnel diode neuristor. When the axon is at rest, it was found, the potential across its membrane is about 60 millivolts (the interior considered negative). The interior is normally rich in potassium ions and poor in sodium ions; the opposite is true of the exterior.

To transmit an impulse, "gates"

LEFT: Tunnel diode neuristor, horseshoe-shaped line four mils wide and about 0.4 in. long, shows some of the properties of axon fiber. RIGHT: Axon, top, compared with tunnel diode, below, appear to function in a similar manner.







IMPULSES are propagated along a nerve fiber by means of local ionic exchanges across axon membrane. No pulses can be sent during refractory period.

along the length of the axon open successively to let sodium ions pour in, thereby making the axon's interior locally positive. A pulse of about 100 millivolts is generated. In the wake of the pulse, the sodium gate closes and a potassium gate opens; potassium ions then flow out of the axon, in this way restoring the original negative or resting potential of the axon.

For a few milliseconds, the axon is locally in a refractory condition and unable to transmit impulses. To restore the chemical balance to the axon, a biological pump whose workings are not fully understood goes into operation.

- **How neuristor works**—One of technology's answers to the axon is the tunnel-diode neuristor. This was suggested when scientists realized that the depletion region of the diode has properties functionally similar to the axon's membrane; and the p and n regions contain the necessary mobile charge carriers, the holes and electrons.

Using the tunnel diode for nerve-like devices was thought of at Stanford Research Institute, Johns Hopkins University's Applied Physics Laboratory, and the University of Wisconsin in the United States, and at the University of Tokyo and Tohoku University in Japan. But NOL claims it is the first to demonstrate an actual device.

The problem confronting Cote while he was working for the Applied Physics Laboratory was to get a long tunnel diode that also had identical electronic properties along every unit of its length. This was pushing the state of the art.

After Cote moved to NOL, he let a contract to RCA, which succeeded in making a germanium device of test quality. It contained two neuristor lines, one four, and the other, seven mils wide. Cote has reported his test results on the four-mil line, which lies inside a half-inch circle formed by the thicker diode.

In making the test neuristor, RCA selectively etched away the n-layer of a large tunnel diode to form line-like n-type mesa structures on a p-type substrate. These are the four- and seven-mil lines.

At present, bias is supplied to the diodes by means of input leads attached at discrete locations along the lines. The same leads are used to trigger breakdown and monitor the propagation.

Future devices are to be made with the bias distributed by means of a conductive bus deposited along the top of the n-type layer. "If it works, this will be a significant improvement," Cote told MISSILES AND ROCKETS, "because it will more nearly approximate the axon with its continuously distributed processes."

When the tunnel-diode lines are triggered, they break down in a localized region. Apparently, the difference in potential between the discharge and adjacent regions sets up lateral currents which, in turn, increase adjacent junction currents to a level sufficient to trigger those regions. The process continues, resulting in a discharge which propagates away from the trigger point in the manner of an axon pulse.

In his letter to the IEEE, Cote described tests conducted on the four-mil horseshoe-shaped line. This diode had five leads connected to it—at the input terminals at the end of each leg, and at the three output contacts shown in the sketch with this article. A 160-nanosecond pulse was propagated from the left-leg terminal to the right-leg terminal at a speed of about 1.1 x 10^5 meters/sec. This compares with the speed of a pulse in a thin axon in a human of less than one meter/sec., and in a large axon, of up to 100 meters/sec.

In the Cote device, a constant voltage bias of 0.62 volts at one amp. was applied to the diode terminals. The tunnel-diode characteristics measured at the three output contacts showed peak-to-valley ratios of 1.48, 1.20, and 1.42, respectively. Cote told M/R that the variation probably was caused by nonuniform electronic characteristics along the length of the tunnel diode.

- **Logic networks**—Complex logic functions can be built up by interconnecting neuristor lines to form appropriate networks. No discrete electronic elements are needed.

For designing a logic circuit, two properties of neuristor lines are basic: destructive collision and reflectionless collisions. These characteristics, described by Crane, may be unfamiliar to most electronic engineers. In a neuristor line, two pulses traveling toward each other are annihilated when they meet. Neither can propagate past the other because the line is refractory on both sides of the impact point. Similarly, a chemical fuse lit at its ends is extinguished when the two flame fronts meet. A neuristor line, however, recovers and can be used again.

When a signal traveling along a linear transmission line meets a discontinuity, the signal is reflected. This is not so in a neuristor line. An analogy is again drawn with a flame front advancing along a chemical fulse. When the flame reaches the end of the fuse line, the fire goes out. Similarly, when a pulse traveling along a neuristor meets a discontinuity in the line or another pulse, the impulse is extinguished; it cannot reflect back across its refractory zone.

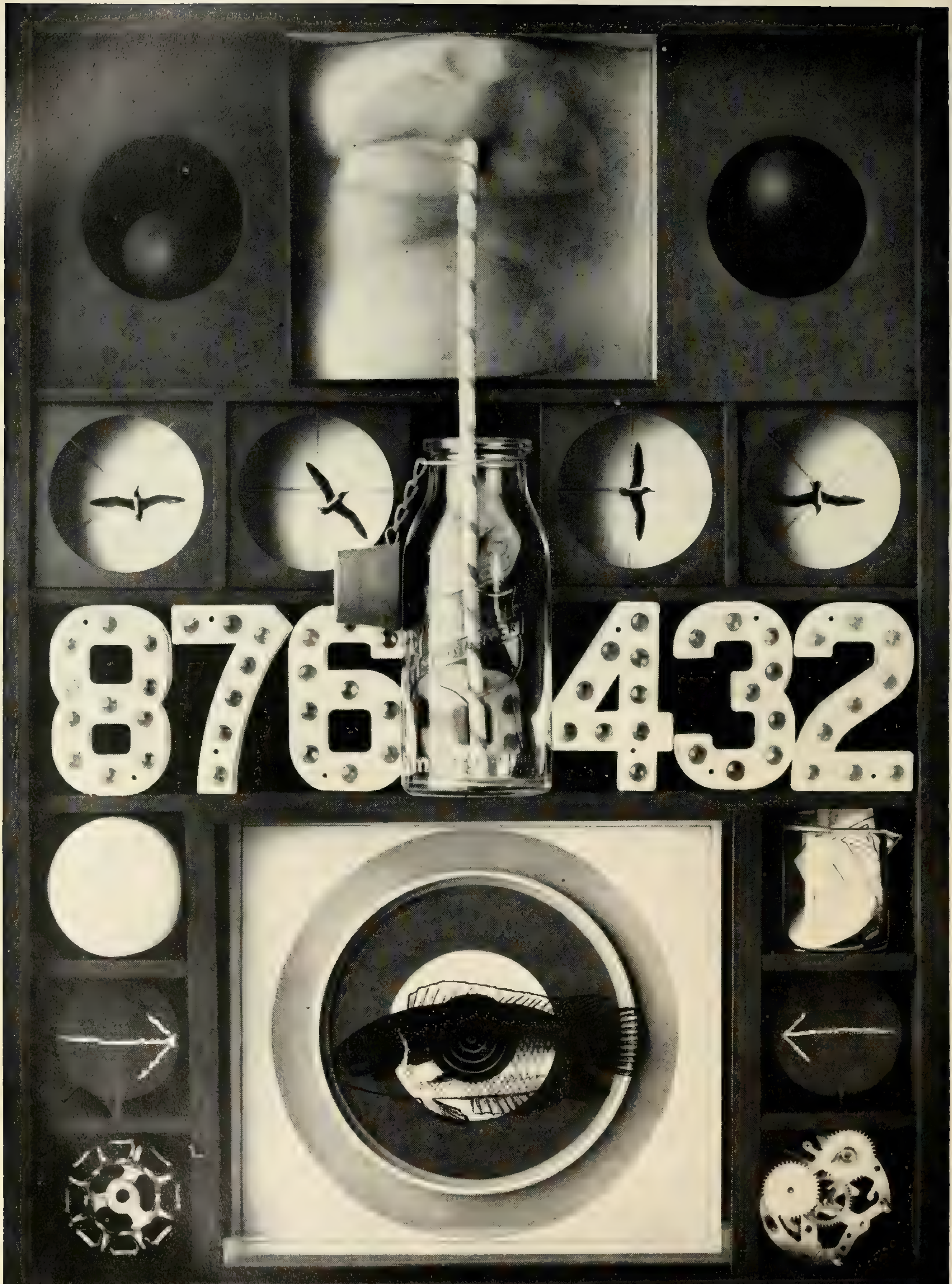
Using these two properties of neuristors as building blocks, designers can devise neuristor relay networks, flip-flop circuits, storage-ring arrangements for computers, and probably any logic network now constructed of more conventional elements.

Another building block for the designer of neuristor circuits is the unilateral junction. By the geometry of the neuristor line alone, it can be made to transmit signals only in one direction. This characteriestic can be used with others to build simple, small and reliable networks.

Cote summarized other advantages of the neuristor by noting that it is easy to fabricate, is immune to radiation effects, exploits the two-terminal aspect of the tunnel diode, and puts electronic design back in the hands of the circuit designers, not the fabricators.

"Some device people must now look into neuristor technology," said Cote. "We've gone almost as far as we are able to here—essentially showing the feasibility of the device."

Many technical problems—such as developing large tunnel diodes with narrow lines and low peak currents—remain to be solved. Analytical tools must also be devised to get the best designs. Yet the biggest problem Cote sees is not technical. It is re-educating many electronic engineers and fabricators so they will first accept neuristors and then see the enormous advantages that they may offer. ■


876 432

Plug-In Hydraulics?

Sure, and no outside plumbing required.

Kearfott's new Hydropack hydraulic control systems are fully self-contained, simple and modular. All they ask of the missile is a command signal and sometimes D.C. power.

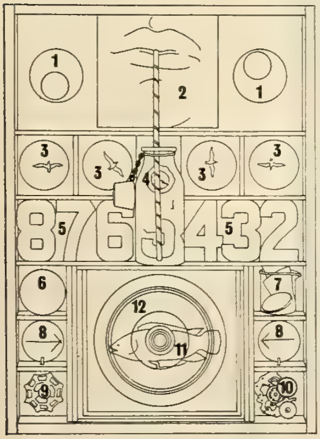
They give back to the missile high reliability and top-notch performance. For example, on the Pershing where 6 Hydropacks are used we know of over 60 flights without a single hydraulic malfunction or failure. A total of 360 successful systems proves reliability.

Hydropack concepts have also been applied to underwater missiles, helicopters, aircraft, hydrofoils, shipboard and airborne radar with complete success. We can build these packages to position 1, 2, 3, 4 or more shafts. They can be shaped like doughnuts, keystones or cubes — in fact, any shape can be provided that will plug-in best in your application.

Hydropacks are always ready. They can be fully operational in seconds whether in tropic heat or arctic cold, (one of the requirements for the Pershing). They can also be instrumented to permit full self-test capabilities without GSE.

As for maintenance, Kearfott's Hydropacks have eliminated the need for field maintenance . . . being self-contained, plug-in modules, a unit can be replaced, if necessary, in less than 10 minutes. No calibration, external adjustments or fluid connections need be made.

Kearfott Hydropacks can keep the pressure off you and where it really belongs. Write today for literature and a reproduction of our latest black box.



This three dimensional collage by Cristos Gianakos is representative of modern missile-borne hydraulic systems. Our key is listed below. (1) Our unique Ball Joint Actuators assure accurate alignment. (2) Old fashioned hydraulics involved forcing fluids through long pipes. (3) Most of our Hydropacks are used for maintaining the "bird's" attitude and (4) direction. (5) Missiles require controls you can count on. (6) Our self-contained, unitized construction approximates perfection. (7) Research has made fluids better than ever. (8) Many forces acting on a vehicle result in the need for positive control. (9) A valve plays an important role in the picture. (10) Quick, sure, on-time response is essential. (11) Some of our actuators are used on underwater "fish" and others on the surface. (12) All contribute to the success of the mission.

KEARFOTT DIVISION

GENERAL PRECISION INC.

AEROSPACE GROUP
Little Falls, New Jersey

Circle No. 3 on Subscriber Service Card

Special Report:
FLUIDICS

Market May Hit $250 Million by '70

Already used in industry for process and other control applications, systems will soon be operational in missiles, subs, ships and aircraft

IN FIVE SHORT YEARS, with an investment of some $30 million, the United States has brought into being a new technology—fluidics.

From scrawled design notes in 1959 to today's prototype flight systems, this basement-born technology has evolved into a research effort costing roughly $14 million a year. Its proponents already are forecasting a 10-15 times expansion during the next half-decade.

Use of fluids as a power source is of course not new, but the discovery that this energy can be manipulated and utilized in much the same way as electricity, in configurations varying from the subminiature to the very large and without need for moving parts, sparked a fire that is steadily widening.

- **Market outlook**—Many industry leaders predict a rapidly increasing annual growth rate during the next decade. Charles L. Davis, vice president in charge of the Honeywell Military Products Group, predicts a $250-million gross market by 1970. Others forecast $150-200 million.

These estimates appear extremely optimistic, considering that the total market for 1964 was only some $14 million. This breaks down as follows: government in-house-funded R&D—$2 million; industry in-house funding and industrial sales—$5-6 million; government-funded R&D (to industry)—$6.4 million. The latter divides roughly this way:

Air Force—$4.0 million
Army—.9 million
Navy—.7 million
NASA—.8 million

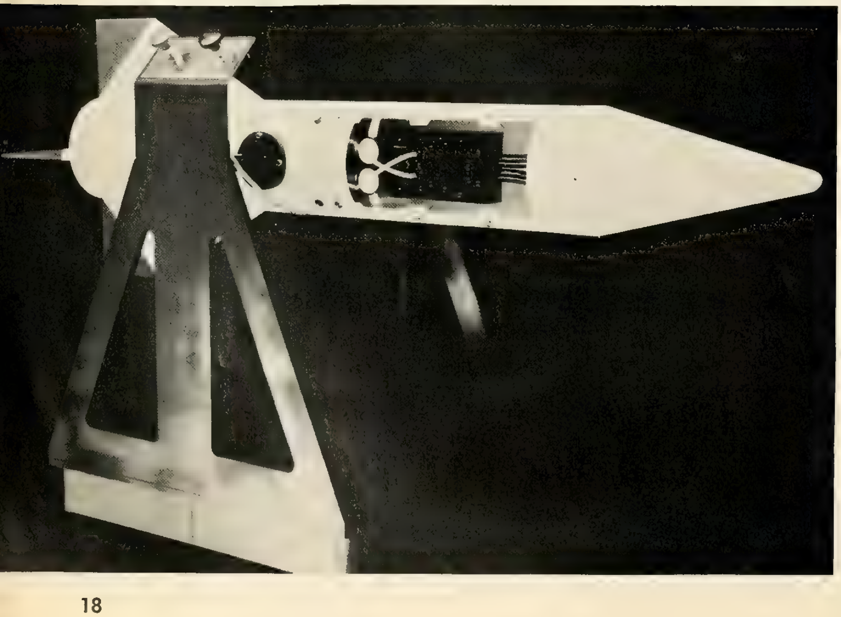
The military R&D market is rapidly changing from basic component development to system studies and development. Principal areas of interest are submarine, torpedo, missile and aircraft control and stabilization systems; artillery and missile arming and fuzing subsystems; submarine secondary propulsion; jet engine, boiler and turbine controls; and guidance and navigation subsystems, including computers and inertial sensors. (See table on p. 26 showing predicted development rate for stabilization and control systems through 1970.)

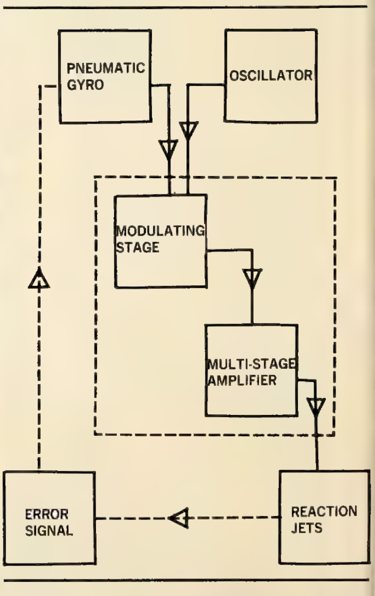
- **Fluidics as a field**—The term "fluidics" as used throughout this report refers to that field of technology that deals with the use of fluids, either gaseous or liquid, in motion to perform functions such as signal or power amplification, temperature or rate sensing, logic or computation, and control.

Inherent in the term is the concept of achieving amplification or gain—and, often, the absence of moving parts.

In the first fluidic circuits developed by Harry Diamond Laboratories, a fluid stream of relatively high energy was directed across a cavity. Through introduction of a low-energy control stream perpendicular to one side of the power stream, the latter can be deflected into a desired outlet aperture,

LEFT: Missile stabilization system is tested by engineers at Harry Diamond Laboratories, Washington, D.C., in laboratory test vehicle. Much of important early work in fluidics was done at Diamond. RIGHT: Block diagram of system in photo.





through which it will continue to flow until deflected momentarily by a control stream from the other side. Thus, the power stream can readily be directed into either of two channels at will. From this simple geometric "gingerbread man" a multitude of progressively more sophisticated devices have been built.

By combining or cascading fluid amplifiers, enormous gains can be achieved from a very low initial input.

Honeywell considers all fluidic devices as falling into one of three major classes: sensors, amplifiers or logic elements, or actuators. From these, complete fluidic systems can be built, using either analog or digital techniques.

Sensors detect some physical condition or change, and provide a fluid signal as an output. Amplifiers or logic elements can build up this signal and process it or store it. The actuator can then be instructed to act on this processed signal and possibly perform some physical action.

● **History of fluidics**—The groundwork for what may now be called the field of fluidics was laid by many persons during the last century, working with pneumatic and hydraulic systems.

One might start with Chichester A. Bell, who developed a turbulence amplifier in 1892. The device found use in Europe as an acoustic sensor and amplifier (at low frequencies). Or one might include the work of R. E. Hall, who developed a turbulence amplifier used as a logic control device.

Certainly a key to modern fluidic technology was provided by Henri Coanda in 1932. Called the Coanda Effect, the phenomenon involves the tendency of a fluid stream emerging into a throat area to attach to one wall. Coanda found that applying a small pressure perpendicularly to the side of the jet nearest the wall would cause the stream to attach to the opposite wall.

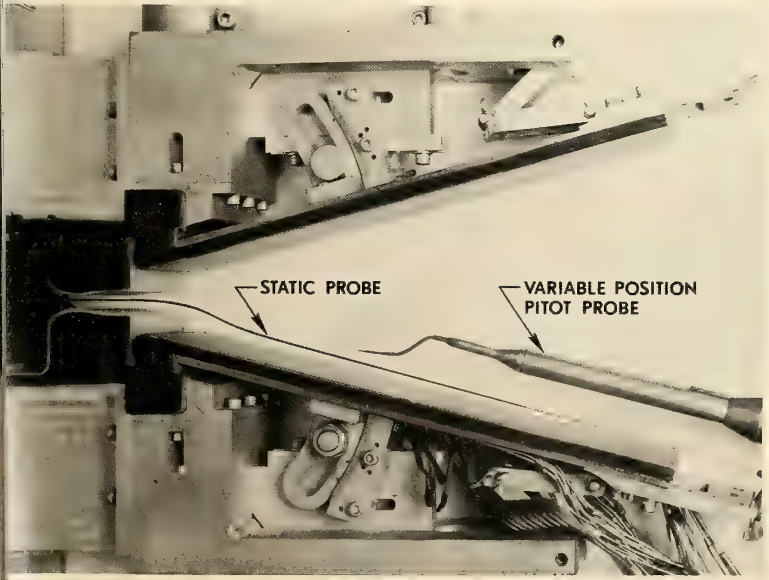
However, no matter how close the early inventors came to fluid amplifiers in their designs, none really recognized or understood the meaning or fundamental use of signal gain.

In 1959, Dr. R. E. Bowles and Billy M. Horton of the then Diamond Ordnance Fuze Laboratories (now Harry Diamond Laboratories) were discussing some work by Bowles in the realm of fluids in motion—more specifically, dynamic fluids and functional performance associated with vacuum cleaners and firefighting equipment.

Out of this casual talk came a suggestion by Horton to use control jets. Thus the concept of fluid amplification and, thereafter, potential application of systems or components using such techniques.

Horton during the next few days nearly filled an engineering notebook with sketches and design notes. Working at their homes, Bowles and Horton, assisted by another DOFL engineer, Ray Warren, soon developed a handful of working components including inertial sensors, amplifiers and logic devices.

FUNDAMENTAL FLUIDICS research is made possible by this large-scale test rig designed by United Aircraft under contract from Harry Diamond Labs. This configuration is used in studying jet reattachment characteristics in wall-attachment digital amplifiers. Traversing pitot pressure probe and sliding static wire probe enable flow profiles to be easily obtained at any axial station desired.



With these ideas and designs in hand, the three inventors were able to obtain Army funding to begin a limited R&D effort.

Horton filed for a patent in October, 1959, refiled in September, 1960, and obtained the key fluidic patent for a "Fluid-Operated System" in February, 1964. He also secured patents for a "Negative Feedback Fluid Amplifier" and "Fluid Systems for Aircraft Control."

Bowles and Warren also secured a basic patent covering sidewall control effect, and thus the three held a firm grasp on a new field.

This latter patent covers a whole family of digital devices using wall interaction.

● **Current patent situation**—The three basic patents issued to Bowles-Warren and Horton covered the fluidic devices mentioned above and also a fluidic bistable (flip-flop) element, oscillator and a positive feedback device. All have held up in a continuing series of interference proceedings.

Bowles left DOFL in 1961 to establish his own firm specializing in fluidics R&D. Subsequently, rights to the three basic patents were purchased by Bowles Engineering Corp. from the inventors.

The Government enjoys a royalty-free benefit included in each patent, and BEC freely licenses reputable manufacturers for unrestricted use of the patents.

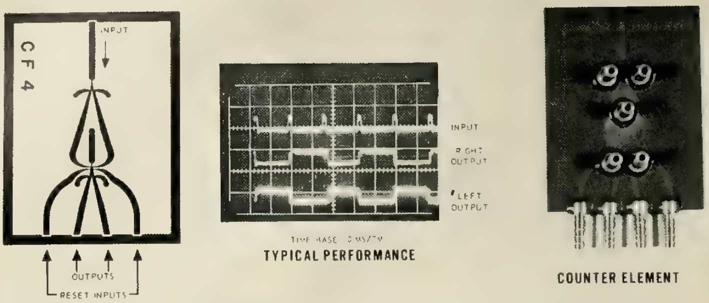
Three interferences filed by Bowles against the Soviets were terminated recently by the U.S. Patent Office in Bowles' favor. The firm has filed three more against Sperry Rand and one against General Electric Co.

BEC also has purchased rights to four other patents issued to the three inventors. The firm now has more than 25 of its own patents pending.

Sperry Rand has filed nearly 150 disclosures, out of which it probably will secure 100 patents. Kollsman, Honeywell, Bendix, GE and IBM hold important fluidics patents and are steadily enlarging their claims.

● **Fluidics impact**—The concept of using fluids to perform electronic-like functions has sparked considerable international interest in fluidic logic and control devices. Japan, for example, is developing an automatic gasoline dispenser and a precision rotary transfer machine controlled by pneumatic logic. Russia reportedly has in production systems which use a fairly complete spectrum of discrete as well as proportional fluid elements.

Japan is using primarily miniature spool valves and Russia diaphragm-type devices, although each is also exploring the no-moving-part concepts. At least two Soviet orbital spacecraft



SIMPLIFIED PROFILE

TYPICAL PERFORMANCE

COUNTER ELEMENT

RESET COUNTER ELEMENT – THIS MODIFIED COMPLEMENTING FLIP-FLOP ELEMENT HAS ADDITIONAL CONTROL INPUTS TO THE BASIC MEMORY UNIT. THESE INPUTS ALLOW THE USE OF A SET OR RESET SIGNAL TO START THE COUNT AT ZERO OR SOME PREDETERMINED CONDITION

THIS FLUIDIC resettable counter element, developed by Bendix Corp.'s Research Laboratories, is typical of dozens of catalog items now available from the firm. Others include binary counters, oscillators, gates, logic elements including AND, NOT, OR plus pulse slicers and stretchers.

are known to have operationally employed fluidic subsystems—one digital, the other analog.

In the U.S., the no-moving-part technology has been receiving the most attention. However, the primary motivation for using fluid devices today is still their unique ability to deliver a controlled force. Simple, lightweight, rugged, and eventually cheap fluid analogs of electronic devices will be developed but have not yet arrived.

There are several reasons:

Fluid particles do not act like electrons. They move in erratic random patterns. Their kinetic energy is directly related to temperature, while electrons do not share at all in the thermal energy of the conductor. Proportional fluid devices are thus quite sensitive to environmental conditions—more so than electronics. However, in certain limited applications where high precision and stability are not necessary, proportional techniques may prove useful.

One promising approach is provided by digital techniques based on wall-attachment devices. Complex digital circuits have been successfully demonstrated over a wide range of environmental conditions. The problem is that thousands of discrete elements are required and must be miniaturized to attain usable operating rates.

● **Missile/space uses**—Autonetics Division of North American Aviation thinks the most promising applications of fluidics in space/missile use are in atmospheric control systems capable of utilizing extremely fast response and minimum space and weight, as well as control systems where ruggedness of design is mandatory and high production techniques are applicable, and in situations that exhibit environmental and radiation conditions detrimental to electronic devices and techniques.

Project Engineer D. K. Benson feels that despite apparently over-optimistic estimates by some specialists in the field, these devices will not supplant major electronic devices in the near future. He does believe however, that there is a very definite need for these devices to supplement the electronics technologies and to provide capabilities not previously available.

He thinks that the long-range marketing aspects for fluid devices are extremely attractive, and the principal gains should be made in applications to complete systems. The performance characteristics that these devices and technologies offer highly recommend them for control system applications, and possibly for inertial instrumentation and computation related to such control systems. They undoubtedly will be utilized within both the atmospheric and marine environments. At present, the practicability of space application is not readily apparent, he said.

● **Other opinions**—J. T. Sharpsteen, Manager, Advanced Programs, Consolidated Systems Corporation, believes that fluidics will never replace electronics in most aerospace applications. The question of reliability can be argued either way and will be settled only by experience. However, fluidic systems should find their niche in environments where electronic systems are not suited—such as nuclear radiation, high temperature, intense shock and vibration—and in situations where for special reasons a fluid device or simple fluid circuit can replace a complex electronic circuit.

Sharpsteen also feels that the real future for fluid devices will be in digital rather than analog systems because of their inherent non-linearities.

He thinks one of the biggest deterrents to fluid logic acceptance is, and will be, the difficulties involved in interfacing components to form circuits.

Robert Muffley of Stanford Research Institute thinks there may be a number of small applications for which fluidics could be peculiarly suited.

He feels that computers *per se* are not a good application of fluidics unless a real breakthrough in speed is made. He thinks the problem with peripheral equipment is the existence of a serious interface problem, particularly where data links are involved. Even though fluidics look attractive for keyboard equipment and certain speeds of card reader, the interface problems will probably dictate against them.

● **Practical uses**—Process control is a practical area for fluidics. Although there has been a trend from pneumatic control to electronics, pneumatics are still used by about 75% of the installations and this fraction has not changed in the last few years by more than one per cent. One of the reasons for the appearance of the trend to electronics was the intention to use digital comput-

Only one recorder/reproducer can update your data analysis better than any other...

It's called Ticor II

Want on-line reduction capabilities in the lab, complete RFI shielding, reliable single sideband recording, or serial PCM? Start by reading a copy of TICOR II's specs. You'll discover 1.5-mc performance previously thought impossible—like TICOR II's time base comparison between events, held within ±0.5 μsec, anywhere on the tape. Let our coast-to-coast team of experts show you how it's done. TWX 510-866-7099.

Mincom Division 3M COMPANY

300 South Lewis Road, Camarillo, California

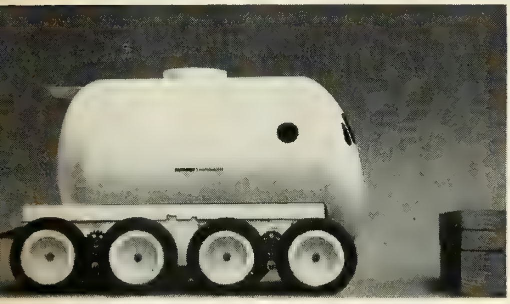
Circle No. 4 on Subscriber Service Card

Where do you test a lunar surface vehicle? On a lunar proving ground. Where else?

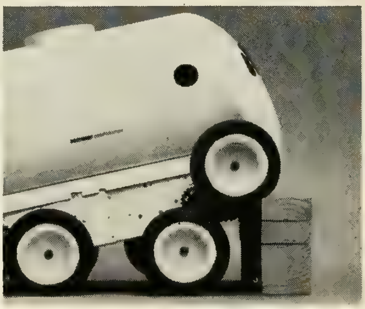
You're developing a mobile laboratory that can be transported to the moon aboard a LEM truck, get itself down off the truck, park in a convenient spot, wait as long as six months for a couple of astronauts to arrive, trundle itself over to meet the astronauts, then take them on a two-week exploration trip of 300 to 400 miles in comfort and safety.

You have a new suspension and drive system which is simpler and more reliable than any of the multitude of other systems you've studied, and which looks as if it could cope with any lunar surface it might encounter.

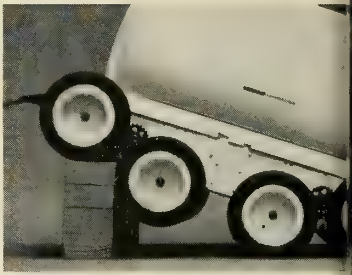
So how do you test it to be sure?



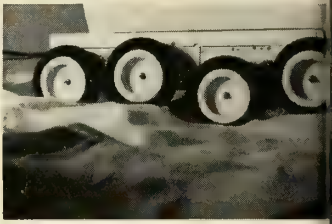
First you build a powered scale model of your vehicle. Then you build a proving ground with obstacles that exaggerate lunar surface problems. And you run your vehicle over the proving ground. Thus . . .



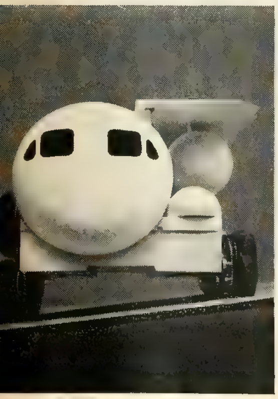
High obstacle with slippery surface. When the vehicle reaches it the driver rotates two of the powered walking beams to raise the front wheels to the top. The front wheels pull, the rear wheels push (all wheels are individually powered).



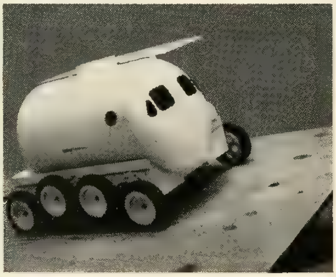
As the vehicle descends the other side, the beams are freed.



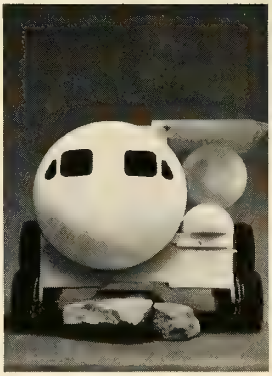
Bumpy ground. Free walking beams let wheels follow contours, reducing pitch and roll, smoothing ride.



or one side.

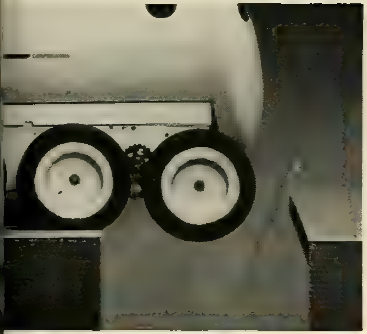


Slippery slope. Weight on four corner wheels gives lateral stability.

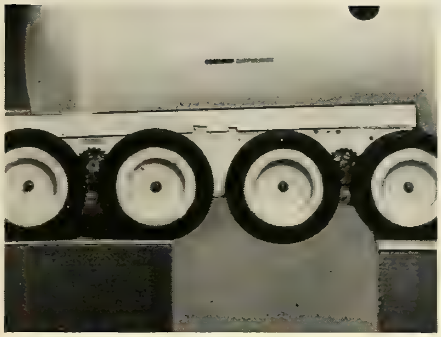


Narrow obstacle. Vehicle rises to straddle it.

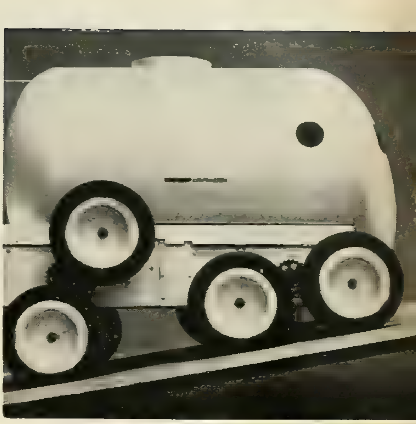
Sharp turns. With scuff steering, vehicle can spin on its own centerline. Eight-wheel drive gives high flotation in soft sand.



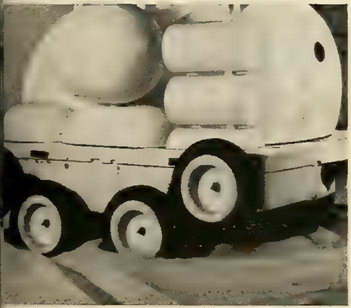
Crevice. Vehicle locks its walking beams . . .



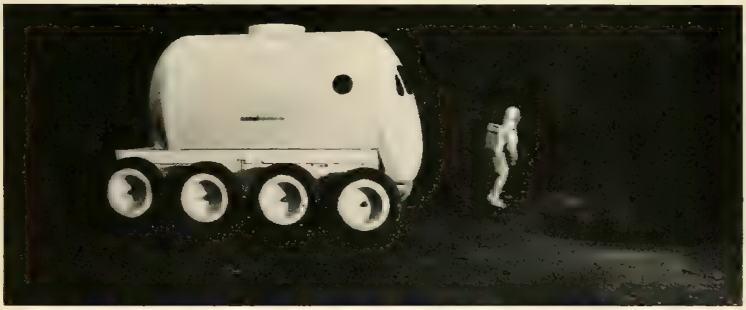
and bridges it. It can bridge crevices as wide as half its wheelbase.



Slopes. Vehicle levels itself by rotating beams at one end . . .



Vehicle can shorten wheelbase for tight maneuvering. If necessary, it can lock wheels and rotate beams to literally "walk" through soft ground.



Can the driver see what lies in the shadows? To find out, create a lunar landscape inside a black chamber with collimated light sources to simulate sun and earth light. Put a TV system in the model and turn it loose to roam the moonscape. You learn immediately that the light is harsh and the shadows very dark. The vehicle will need sun filters on the windows, strong lights to probe the shadows.

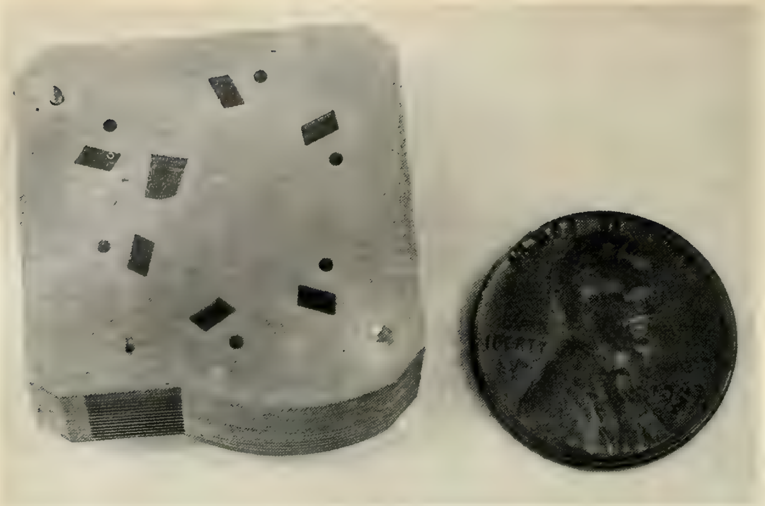
In this vehicle the cylindrical lab module is mounted on one side of the chassis, with the fuel cells and tanks next to it. The driver sits on the centerline. Optical and TV systems permit him to view all the wheels.

The pressurized cylinder contains two compartments – the spacious main lab and a two-man airlock and flare shelter. A small airlock on the side permits samples to be passed inside or worked on in lunar vacuum. The command module docking adapter on top provides an emergency escape hatch.

The vehicle can be remotely controlled from the lunar surface, from the orbiting command module, or from earth.

The market for two-man moon campers is still quite small, but we expect it to grow. We intend to be ready with practical and proven designs to meet the demand when it comes.

NORTHROP



HIGH-DENSITY 14-bit binary counter module developed by Martin-Orlando is composed of 1-in.-sq. planar logic elements and transfer passages stacked to provide complete system. Any desired counter capacity can be obtained.

HONEYWELL PREDICTIONS:

Fluidic System Developments for Vehicle Stabilization, Control and Navigation
(1965-1970)

	System	Component Development Making System Possible	Typical Applications
1965	Directional Control	± 10-deg angular freedom displacement gyro	Straight-line-of-sight missiles
	Tight "Attitude Hold"	± 10-deg angular freedom displacement gyro	Helicopter as gun platform; air-ground missiles
	Thrust Modulation Control, rate damping	Multiplier	VTOL hovering; engine failure protection
	Straight-Line-of-Sight Missiles, integrated rate system	Improved integrator	Short-time-of-flight, line-of-sight missiles
	Flight Path Stability Augmentation	Accelerometer (also concept development)	Short-term "flight path hold"
	Hybrid All-Attitude Autopilot	Conventional all-attitude gyro, electrical-to-fluid signal transducer	Transports, VTOL, STOL, fighters
1966	**Guidance Systems, Point to Point**		
	Stabilization and Control with Command Input	Electrical-to-fluid signal transducer Special moment producers Improved amplifiers A/D and D/A converters	Command and homing missiles, VTOL, STOL, helicopters
	Preprogrammed Guidance	Computing elements Shaping networks Interface with programmer	Air-ground missiles
1967-1968	Preprogrammed Guidance	All-attitude fluid gyro programmer	Long-range missiles, space vehicle payloads
	Manned Aircraft, Complete Flight Control		
	All-Attitude, Fluid Autopilot	All-attitude fluid gyro "Outer Loop" tie-ins	Transports, VTOL and STOL, fighters
	Navigation Systems		
	Interim General-Purpose Navigator	Gas-bearing gyro Electrical A/D conversion El to Fl transducer Navigation and direction cosine computers	Tactical aircraft, some transport missions
	Interim General-Purpose Navigator	Fluid A/D converter	Tactical aircraft, some transport missions
1970 or beyond	General-Purpose Navigator (displacement gyro type)	High-performance, all-attitude gyro	Same
	General-Purpose Navigator (rate sensor type)	High-speed computation, high performance from all components	Same

ers for process control; this move took place about five years ago and is not so evident now.

In fact, in process control, pneumatics is still the cheapest way to go. It is about $100 per loop cheaper. For this reason, pneumatics will be used for a long time to come. Fluidics offer the possibility of low-cost devices such as summers, integrators, and function generators, which are difficult to mechanize in conventional pneumatics, where use of carts and wheels is involved. A firm that could offer a simple fluidics functional package probably would find a large market.

Another area of application is in industrial control, in non-continuous processes like machining. This is the reverse of the computer situation. Transit times involved are those of heavy objects, and fluidics devices offer the possibility of doing away with many of the transducers involved in going from microswitch circuits to pneumatic circuits to hydraulic circuits. Transducers may cost $25-30; an installed industrial relay costs $12. Packaged fluid amplifiers available for standard systems could be a real threat to relay systems and would do away with interface costs.

● **Bright future**—While many observers have likened the development of fluidics as an industry to that of the semiconductor field, the relation of fluidic circuits to conventional hydraulic and pneumatic systems is not a progression of technology, like that represented by transistors with respect to the vacuum tube. Fluidics is a step advance. It provides a promising new method of utilizing energy.

Fluidics will replace electronics in some systems applications. In general, however, the future of fluidics must hinge on its use in applications where it is not only the best or most economical approach but often, indeed, the *only* approach.

In environmental conditions of extremely high temperatures, intense radiation or severe shock, fluidic systems can solve problems that might never be solved with other techniques.

Fluidic circuits may well revolutionize at least two aspects of medicine, with the development of respiration-assist devices and fluidicly controlled mechanical hearts. It is not inconceivable that within the next decade a successful heart replacement will evolve. (Work in this area is progressing rapidly at Harry Diamond Laboratories in conjunction with the Army's Walter Reed Hospital in Washington.) Furthermore, greatly improved prosthetics will be produced through application of fluidic control techniques.

The future of fluidics appears bright. The benefits across the board will be enjoyed universally. ■

supervisory engineers • computer programmers • systems engineers • math analysts
data processing analysts

become part of the continuing growth picture at the **U. S. AIR FORCE WESTERN TEST RANGE *with* FEDERAL ELECTRIC CORPORATION**

Federal Electric Corporation is responsible for the range safety aspects of the WTR at Vandenberg AFB in California. We are responsible for the acquisition, tracking and in some instances, the termination of missile flight. Radar tracking, analog and digital data transmission, telemetry, communications, command destruct, real time programming, operation and display are some of the functions performed by FEC. Not only do we operate and maintain these systems, but we must analyze and evaluate them to verify system specs and to assure system capability for new and expanding programs which are part of the ever changing, dynamic technical environment at Vandenberg AFB.

SYSTEMS ENGINEER

Will analyze and evaluate precision pulse, conical scan and interferometer tracking systems to determine and minimize random and systematic errors including dynamic lags, thermal noise, system calibration errors and servo noise. Will determine refraction errors, propagation medium losses and multi-path errors. Will evaluate missile beacons and antenna patterns to determine signal levels and systems ability to track. Will develop and direct the performance of system tests and computer programs for verification of system capabilities, post launch, quick-look evaluation and trend analysis studies. Minimum requirements include a BSEE and 2 years experience in systems engineering related to radar.

MATH ANALYSTS

Work on problems in orbit determination, impact prediction, trajectory analysis, error propagation due to radar and orbital sources of error, atmospheric physics, astrodynamics, statistical estimation and communication theory. These areas of investigation furnish the analytical treatment of math models associated with missile launch support. Requires BS in math or physics; MS preferred. At least three years' experience related to missile range support, satellite tracking, or trajectory analysis required.

SUPERVISORY ENGINEER

Supervise section engaged in: design of systems analysis, comparative analysis and correlation programs for range systems. Evaluate tracking systems using various techniques of stochastic analysis. Determine error sources and magnitudes of subsystems such as servo noise and servo dynamic errors. Institute performance criteria for digital systems utilizing the auto-correlation function. Determine system degradation loss. Specify data requirement and special systems tests to insure that current WTR technical requirements are being satisfied. Develop systems performance tests and techniques for post-launch, quick-look systems evaluation. Requires BSEE. Advanced degree in systems engineering or EE desirable. Minimum of eight years' electronics engineering experience required, two years of which were in a supervisory capacity and two in systems engineering.

COMPUTER PROGRAMMERS

For Real-Time, Scientific, and Systems Applications associated with range launch support and implementation of data reduction systems including real-time missile tracking and impact prediction trajectory analysis and simulation and post flight data reduction. Requires BS degree in math, engineering or physics and a minimum of one year's experience on IBM 7000 series machines with a working knowledge of FORTRAN and FAP.

DATA PROCESSING ANALYSTS

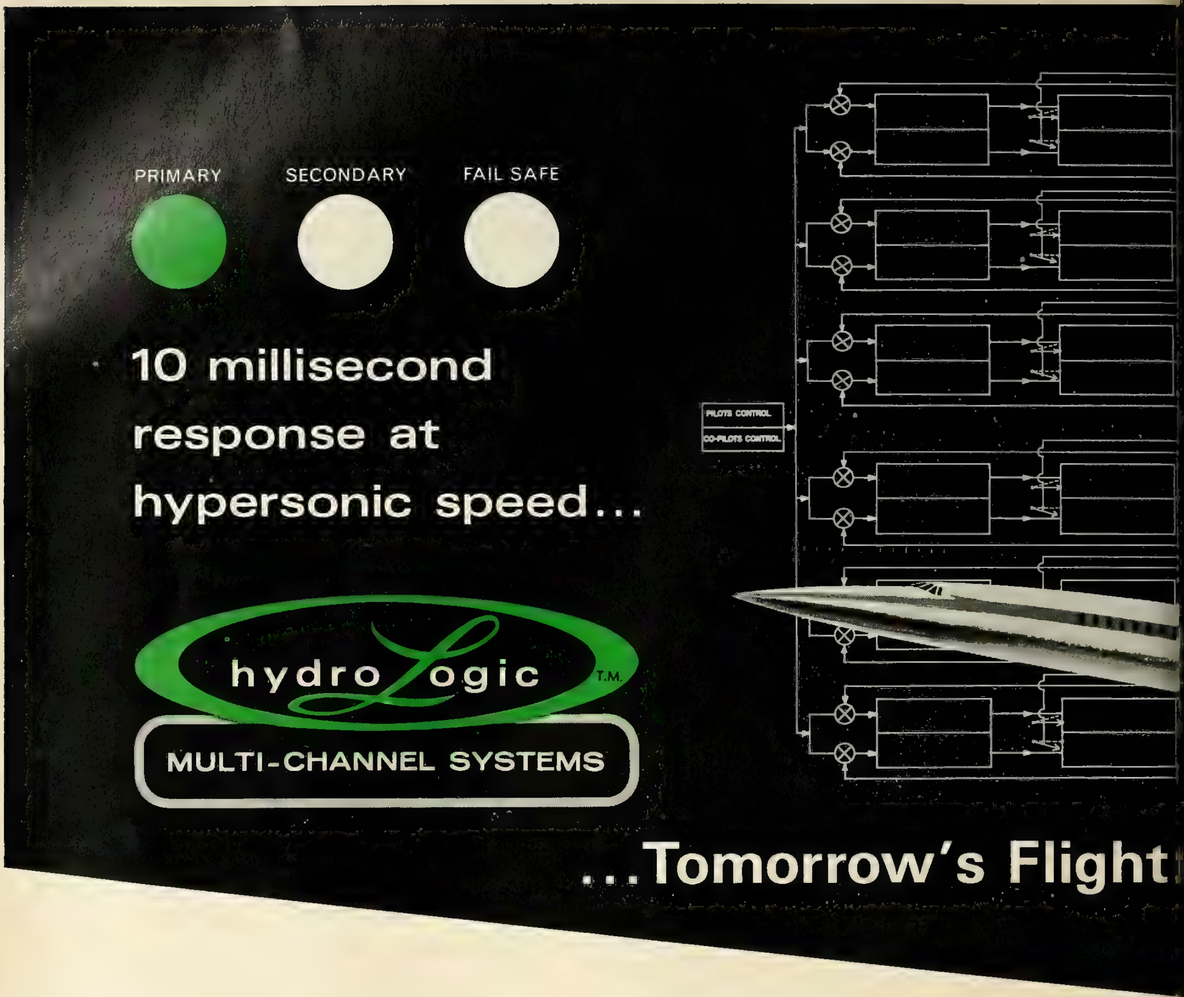
Analyze, edit and prepare electronic, optical and telemetry data for launch by launch range data processing effort. Data will include information from pulse radar and interferometer sensors, metric film and missile borne telemetry. Processing will be accomplished by the use of IBM 7094 computer system. Requires BS degree in engineering, math or physics and 2 years' experience in analysis of missile flight data.

Forward details of your background indicating education and experience as well as salary requirements. Address:

Mr. M. Schrock, Federal Electric Corporation
Box 446, Lompoc, California

ITT
service

FEDERAL ELECTRIC CORPORATION
An Equal Opportunity Employer



In 1957 the first Hydomat, a packaged multiple-channel servosystem, was installed on the F-106 Delta Dart. Designed and manufactured by Hydraulic Research, the Hydomat gave military aviation a fundamental new systems concept. Responding with utmost reliability to either manual, autopilot or damper control input, the Hydomat brought unparalleled safety and reliability to second generation jet aircraft.

Seven years of flight service have demonstrated the dependability and performance integrity of the Hydomat concept. Over 4,000 Hydomats have accumulated in excess of a million service hours on a variety of supersonic military craft with a MTBF* of 24,559 hours!

Product refinement—in advance of need—is the continuing goal of development engineering at Hydraulic Research. Today, in anticipation of even more critical reliability requirements of Third Generation military-civilian jetcraft, Hydraulic Research has again advanced the state-of-the-art in systems design through the development of packaged hydraulic redundancy of unmatched speed and reliability.

hydroLogic servosystems provide instantaneous failure detection and channel changeover coupled with uninterrupted performance integrity. In 10 milliseconds hydraulic logic activates a standby systems control channel!

hydroLogic systems provide automatic failure detection and removal without use of costly electronic componentry of doubtful dependability.

*Mean Time Between Failures

A
textron
COMPANY

HR

HYDRAULIC

2837 North Naomi

Circle No. 5 on Subscriber Service Card

①
②
HYDRAULIC
COMPARATOR
③
④
⑤
DRAULIC
PARATOR

rol System Today!

Consider these advantages of all-hydraulic redundancy:

SIMPLIFICATION hydroLogic systems eliminate up to 75% of the interconnections characteristic of electro-mechanical controls. Important weight and space savings can thus be achieved.

TEMPERATURE RESISTANCE hydroLogic systems perform efficiently at the sustained high temperatures associated with supersonic flight.

MAINTAINABILITY Capable of optimum performance at *elevated temperature control points* (e.g., wing environments) ...hydroLogic systems are readily accessible and replaceable, thereby minimizing long term maintenance costs.

RESPONSIVENESS hydroLogic systems achieve their essential mission—failure detection and correction—in 10 milliseconds.

RELIABILITY The performance integrity of the hydroLogic systems concept has been demonstrated by a million in-flight service hours. Only hydraulic redundancy provides this optimum level of reliability.

■ **If hypersonic flight control is your responsibility, you are invited to contact Hydraulic Research for engineering assistance in connection with specific applications of hydroLogic systems. There is an Hydraulic Research Engineering Liaison Representative in your area.**

EARCH and manufacturing company

nk, California • Telephone: (213) 845-7601 TWX: (213) 846-8814 • Cable Code: HYDCOMP
ing liaison representatives throughout North America and Europe.

Circle No. 5 on Subscriber Service Card

Special Report:
FLUIDICS

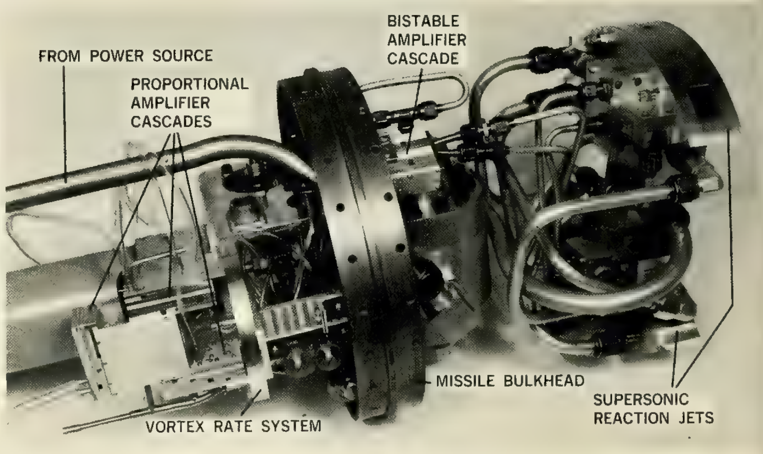
Services Dominate $14-million Market

Military has given technology its raison d'être, but NASA is becoming an important new contractor; an agency-by-agency summary

THE GROWING FIELD of fluidics was born in the military and owes its continued growth to the military. Industry has unquestionably contributed heavily, but its work has been done with a sharp eye on an expanding market within the three military services.

NASA, a relative newcomer to the field, has made itself known and will in time offer a significant fourth source of contract money.

In a present national market totaling roughly $14 million, nearly $7 million is derived from government sources. The following pages summarize the efforts maintained today by the military and NASA and give an indication of the direction of their R&D programs.



FLUID CONTROL system developed by Honeywell for Army's Test Instrumentation Missile includes rate sensor, memory, amplifier cascades, supersonic reaction jets.

Army

The U.S. Army must be credited with being the prime mover in spreading the gospel of fluidics technology through its spokesman and principal developer of the art, Harry Diamond Laboratories. For HDL instituted the first in-house effort, secured the first R&D monies for industry, and has steadfastly promoted the field of fluidics.

That other military services may now have passed the Army in fluidics R&D funding is only a reflection of how well HDL performed its task of selling the potential of fluidic systems.

In addition to its regular drum-beating, HDL has been the originator and sponsor of two fluid-amplifier symposia and has generated, through its technical personnel, the bulk of all technical papers presented or published since 1959 in the field of fluidics.

Total fluidics funding at HDL for FY '65 is about $1.4 million—with over $600,000 of this going to industry. Three-fourths of the HDL fluidics effort in-house is directed toward Army R&D, the remainder to other government agencies.

The accompanying chart reflects HDL contracts as of December, 1964.

The lab employs 30 technical personnel for fluidics research and eight for system development, principally in the area of missile thrust-vector and reactor control.

To summarize fluidic component research and development at HDL since 1959 would but produce a mirror image of almost the entire fluidics field. Efforts now are concentrating on better device understanding, interconnections, system development methods, better fundamental understanding of vortex rate sensors,

HARRY DIAMOND LABORATORIES' CONTRACTS FOR FLUIDICS, FY1965

(in thousands of dollars)

CONTRACTOR	PURPOSE	COST
Naval Ordnance Lab	Classified	11.8
Picatinny Arsenal	Hot-gas generators	8.8
Johnson Service Co.	Proportional fluid amplifier	3.1
Case Institute	Pure-fluid encoding system	10.4
Purdue University	Research in fluid mechanics	2.5
Catholic University	Pure-fluid systems study	10.7
Franklin Institute	Research in pure-fluid systems	13.3
Oklahoma State University	Mixing theories	15.0
Maryland University	Research in pure-fluid systems	11.4
Maryland University	Two-dimensional jet flow	4.8
Johnson Service Co.	Pure-fluid impact modulators	30.0
University of Nebraska	Sink-vortex motions	6.8
University of Nebraska	Splitter-plate geometry	7.9
United Aircraft	Attach streams to walls	94.8
Illinois Institute of Technology	Two-dimensional turbul. jets	40.0
United Aircraft	Fluid devices	2.2
Corning Glass	Fluid-amplifier computation components	29.9
Naval Ordnance Lab	Testing rocket-steering devices	15.0
United Aircraft	Compression flow & dynamic resp.	50.0
Illinois Institute of Technology	Study of noise & of stream interaction	30.0
University of Nebraska	Effect of vortices	20.0
MICOM	Testing jet steering	40.0
Honeywell	Improving fluid gyro	45.0
Sperry Utah	Coanda effect	20.0
(To be awarded)	Fabrication	30.0
Bowles Engineering	A.C. fluid circuits	9.0
	TOTAL	563.1

acoustical effects on fluid flow, component response and determinations of transfer functions.

• **Other Army groups**—While HDL represents the heart of the Army Material Command's fluidics effort, there are other Army centers concerned with fluidic systems applications. These include Redstone Arsenal, Picatinny Arsenal, Frankford Arsenal, the Limited Warfare Center (MICOM) at Fort Eustis, and Aberdeen Proving Grounds.

Redstone probably has the Army's second largest effort. Honeywell is developing and has already flown a fluidic missile flight-control system. Giannini Controls is working on a double-leg-elbow amplifier and aerodynamic throat modulation.

General Electric, under a Picatinny Arsenal contract, is developing a fluidic timer for a variety of ordnance applications. The unit is a resettable, digital fuse timer operating off of ram air and includes a fluidic oscillator, frequency divider and counter.

Honeywell is developing a tactical missile flight control device for Frankford Arsenal.

Bowles Engineering has developed a timer for a leaflet-bundle braker for Aberdeen.

Air Force

Following disclosures in 1960 by Harry Diamond Laboratories of the potential uses of fluidic circuits and subsystems to industry and the various interested government agencies, the Air Force Systems Command began its own R&D effort. It has broadened rapidly ever since.

• **AF Flight Control Lab**—In 1960, Bendix Eclipse-Pioneer Division had been working for the Flight Control Division of the AF Flight Dynamics Lab., Research and Technology Division, at Wright-Patterson AFB on an extensive R&D program associated with supersonic aircraft. It had been looking into various pneumatic subsystems. With the HDL disclosures, the group began a low-effort fluidics study that quickly grew in magnitude.

The five-year effort, funded at a total of $1.2 million, culminating this month, was modified to include studies and a development effort for a fluidic rate sensor and compensation networks. Much of the original Bendix effort had been centered on development of a hot-gas servo actuator system. With the shift to fluidics, a proportional actuator system was developed.

The present system operates on hydrogen-peroxide at 1,360°F and at a 600-psi input. It is generally believed that Bendix invested nearly a half-million dollars in the development of the system to build its fluidics capability.

There has been another continuing AF program at Massachusetts Institute of Technology. Funded at a rate of about $70,000 per year, MIT has for about five years been investigating fluidic technology, attempting to provide stronger analytical support for fluidic system design. The group has looked into digital or pulse-rate components, and this effort resulted in a development effort for a pseudo-digital stabilization system concept for pitch-axis control of a hypothetical advanced aircraft. Bendix was given a $300,000, 17-month contract to produce such a system in April, 1964.

The Flight Control Division awarded Honeywell a one-year, $100,000 contract in March, 1963, to study applications of fluidics to several hypothetical aerospace vehicles.

The following April, Giannini Controls was given a one-year, $90,000 contract to study a fluidic ratio measurement and computation system. The firm is determining methods for measuring air data and will design, fabricate and test at room temperature a pneumatic ratio computer (static, dynamic pressure).

Contracts from the Flight Dynamics Lab over the past four years have totaled roughly $2 million.

• **Avionics Lab**—The Navigation and Guidance Div., Avionics Lab., AF Research and Technology Division, at Wright-Patterson AFB also has maintained a strong fluidics effort which began in 1961.

Honeywell received a two-year, $100,000 contract in March, 1962, to study the vortex rate sensor with a view toward a better analytical understanding of the device and to improve its performance for aerospace vehicle use.

In July, 1963, the firm received a 14-month, $600,000 Phase 1 study contract to perform a comprehensive applied research study of fluidic applications to inertial navigators. This included development of a fluidic accelerometer, determination of navigation equations needed with fluidic sensor/computation systems, and a study of the fluidic elements needed for integration into a working flight system.

The firm also studied interconnection problems and minimum and maximum fluidic system capabilities.

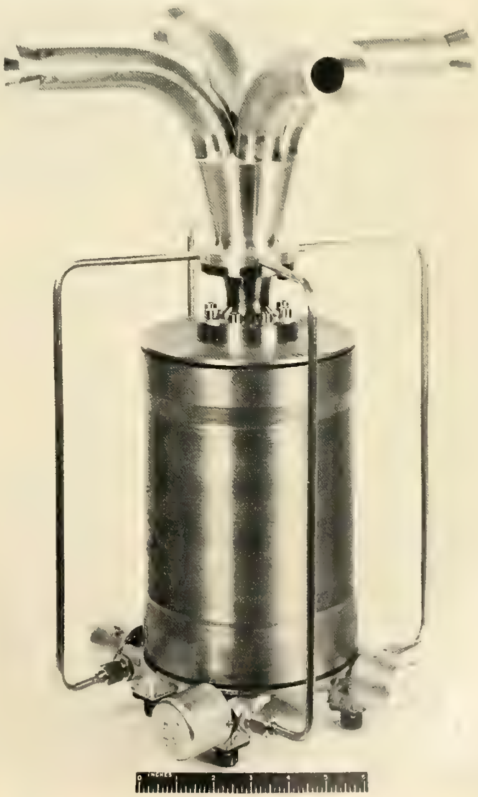
The report from this effort is now being analyzed by the Avionics Lab. It is expected that another 9 to 12 months will be needed to complete the task; in the meantime, the Lab is not planning to let any other fluidics contracts.

• **Aero-Propulsion Lab**—A third AF/FRD group concerned with fluidics technology is the Aero Propulsion Laboratory at Wright-Patterson AFB. It awarded a 15-month, $420,000 contract to Honeywell in December, 1963, to demonstrate feasibility of a jet engine (J85) control system using fluidic techniques at sea-level conditions.

In associated projects, Harry Diamond Labs is funded for a one-year, $40,000 effort for temperature sensor development, ending this August, and Cornell Aeronautical Lab is working on an 18-month, $160,000 contract awarded in November, 1963, for development of a pneumatic flow-instability sensor for advanced turbine engines.

Marquardt Corp. also has been

ADVANCED thrust vector stabilization control system developed by Harry Diamond Laboratories is pure-fluid, will be tested aboard missile at Redstone this spring.



awarded a contract for development of a propulsion control system for an unspecified amount. Details are classified.

General Electric also holds an Aero Lab contract to develop a position servo for advanced jet engines.

- **In-house effort**—The FTD in-house effort at Wright-Patterson has in effect been pooled. The groups have established a central lab provided with some $150,000 worth of instrumentation.

The present primary effort is directed toward problems of long-transfer-time, new-amplifier design for pneumatic analog computer circuit information transmission and environmental effects—particularly ambient noise levels.

The group now has only 12 full-time technical personnel working on fluidics, but it hopes soon to draw on students in the AF Institute of Technology, also located at Wright-Pat. Some students already have been involved in Schlieren optical analytical studies of fluidic flow and heat-transfer characteristics.

In time, a series of fluidics labs will be established at the base.

Navy

The Navy's support of fluidics R&D has been relatively low over the past two years, but appears to be increasing slightly. The bulk of Navy funding in this field has gone to Bowles Engineering, Inc. General Electric and Honeywell account for most of the remainder.

- **ONR studies**—The Office of Naval Research has funded two major feasibility studies.

In 1963, Bowles performed an ONR study, designed and built a fluidic speed-control model for a 500-kw sealed steam-turbine generator. A pneumatic system, it demonstrated turbine speed control (at 10 different step loadings of 10%) at 12,000 rpm (±0.1%).

During the same year, GE obtained a related contract to perform a broad computer analysis to determine the relative merits of all-analog, all-digital, or hybrid analog/digital fluidic control systems for use with a steam turbine. Study results indicated that several fluid-amplifier techniques would provide control equivalent to conventional governors.

Honeywell, Inc., is currently performing a broad survey to determine possible applications for fluidic control systems in the Navy.

- **BuWeps program**—Officials here indicated that because Bureau of Naval Weapons R&D funds were relatively low, they have had to use money carefully as a catalyst to stimulate industrial interest. It would appear, however, that most of the catalytic agent was introduced into one pot.

At a funding level of about $200,000 a year, Bowles has been designing and developing fluidic control systems for advanced Navy torpedoes. This project includes development of components and control techniques suitable for high-performance, long-range weapons.

Bowles also is performing a study to unearth fluidics applications to BuWeps hydraulic and pneumatic systems. These include in-flight refueling, fire control, and other aircraft fluid operating systems. A final report is due shortly on this $26,000 effort.

A larger project (in the $50,000 category) is expected to be awarded shortly for the study of the use of secondary air flow to alter aircraft wing characteristics. An ultimate goal suggested in the effort is the design of an aircraft requiring no external moving parts for aerodynamic control. Source of the secondary air, said one spokesman, could be a compressor, an engine bleed system or even a system in which fuel might be burned at the nozzle.

A next step beyond this contract, according to the BuWeps official, might be to configure an aircraft (by modification) with a complete fluidic flight control system and then perform an extensive flight evaluation program. The present effort, however, he pointed out, will not be directed toward any particular aircraft.

He also suggested that a hybrid system could evolve—that is, one using fluidics for high-speed control and conventional controls for low-speed operation.

- **BuShips projects**—If the Bureau of Ships is also employing "catalytic" stimulation, then it too has found the same BuWeps pot.

Bowles has completed one BuShips contract for nearly $150,000 and is now engaged in another for nearly $150,000 to develop fluidic boiler controls for shipboard use.

The firm also is developing a massive fluidic control system for providing submarines with a hovering capability. Under the $50,000 contract, BEC developed a prototype system capable of generating 2,000 lbs. of thrust with sea water jets.

The Navy's Marine Engineering Laboratories, at a cost of another $50,000, has evaluated the device. Its test results have indicated that the Bowles system met design criteria, including thrust output and response. It was found "somewhat noisy," according to a Navy source, and Marine Engineering has been given the task of reducing this noise, which apparently is generated by a turbine pump.

BuShips next plans to go to industry for development of a fluidic computer to provide automatic control of the hover system. Twelve firms are on the bidder list.

If the fund holds out, the Navy will evaluate the hover system aboard a submarine. The hover devices will be operated in pairs and up to two pairs may be needed.

Marine Engineering also plans to study other methods for achieving submarine hover control for comparison with the fluidics approach. This is expected to require 6-8 months.

Other fluidics applications being considered by BuShips include automatic course and depth control, secondary submarine propulsion (using the hover system), and the elimination of submarine control surfaces through use of water control jets.

BuShips presents plans to put a hydrofoil control system on a test vehicle—the FRSH-1, a 15-ton hydrofoil test ship built by Boeing Co. and now in storage at the company.

Navy reportedly plans to go to Bowles as a sole-source for development of the control system. (Bowles has been ready to do so for about seven months.)

The FRSH-1 system fluidics need is based on a nine-month feasibility study, lift sensor development and model test contract with Bowles. Cost was $138,000, and was completed July, 1964.

A complete new foil system is being built by Convair and a pure-fluid lift sensor has been developed and tested, according to the Navy. Logic portions for the system are also built full size.

The control sensor is built into the leading edge of the foil and measures relatively minute pressure differentials. These are translated into lift commands.

The fluidic system consists of a five-stage amplifier, a pressure/flow amplifier, a power amplifier and a foil actuator, Navy officials indicated the approach looks "very promising."

The study also made a "quick look" at jet flap control. No problem with the control portion was indicated, but necessary power levels still remain a problem.

Bowles has also performed a feasibility study of roll stabilization fin control for surface ships. The contract, also for nine months, called for a final report in September, 1964. Project cost was $90,000

NASA

Development of fluidic control systems by the National Aeronautics and Space Administration will proceed more rapidly in the coming year.

The increased funding and activity reflects in large part the achievement, through a number of important study contracts, of more refined estimates of the actual fluidic systems state of the art, the problem areas, and the feasible applications of this technology for the space agency.

NASA scientists are well aware of

SEA-BORNE SPACE WINDOW

A Solution to the Problem of Accurate Vehicle Injection Into Space Mission Trajectories.

Insertion into a parking orbit or transfer from a parking orbit into a lunar/planetary ellipse can take place anywhere within a 6000 by 2000-nm launch corridor in the South Atlantic and South African area bounded by latitudes 15°N and 30°S.

To achieve the required velocity measurement accuracy of 1 ft/sec at 35,000 ft/sec in the injection firing window, increased range tracking capability across the width of the launch corridor is required. One solution, now in the planning stage, is to slave two advanced instrumentation ships to an island-based station in a triangular configuration, maintaining minimum separation of 250-500 nm.

Complex problems in telemetry, navigation, tracking, communications, and data handling must be solved. Of paramount consideration are:

☐ systems to maintain precise time synchronization among stations and Central Control. ☐ systems to measure ship vertical and heading within 30 seconds of arc. ☐ systems to measure range and range rate to the required accuracy. ☐ systems to provide near real-time data handling and transmission among ship/land stations for rapid trajectory-correction information.

On this and other programs, assignments are immediately available to senior electronic engineers with *systems and planning* background in: pulse and CW radar/telemetry/optics/infrared/data handling/communications/closed circuit TV/frequency analysis/command control/underwater sound/timing/shipboard instrumentation.

Address inquiries in confidence to Manager, Professional Employment, Dept. 56B-2.

PAN AM
GUIDED MISSILES
RANGE DIVISION
PAN AMERICAN WORLD AIRWAYS, INC.
750 S. ORLANDO AVENUE, COCOA BEACH, FLORIDA
An Equal Opportunity Employer

Circle No. 6 on Subscriber Service Card

at least the potential economic gains of fluid system manufacture, but the major reason for their interest is the potential reliability of these devices. They feel that the economic advantages may never really accrue to space agency programs because they are likely to require only production quantities.

Expenditure for fluidic systems study and R&D by NASA during FY '66 is expected to be slightly over $1 million, with about $550,000 of this requested for the Marshall Space Flight Center, the major center now involved in fluid systems design. The Lewis Research Center program is also expected to approach $500,000. Smaller, but potentially very important programs, are also being carried out at the Langley Research Center and at the Flight Research Center, Edwards, Calif.

The NASA program, while less urgent and less expensive thus far than the military effort in this field, nevertheless has laid some very important ground work in the past year. It could grow into a substantial market for industry.

For example, MSFC has continued to fund General Electric's Advanced Technology Laboratories and Light Military Electronics Dept., in New York, for a major excursion, on the study level, into the current fluidic system state of the art, areas of feasible application for NASA, problem areas needing development effort, and reliability estimates, among other things.

Early portions of the study, which is now entering phase V, have become basic working documents within NASA, and could easily influence future decisions. Under the contract, totalling nearly $200,000 since its inception in 1963, the company has also provided a much-needed bibliography and fluid amplifier terminology manual.

Another, similar, NASA effort basic to future work in fluidic systems is being undertaken by the Sperry-Utah Co., a division of Sperry-Rand Corp. The firm has just completed an analytical investigation and some experimental work for MSFC on fluid amplifier dynamic characteristics. It is now working at a broad compilation of data and techniques in an attempt to develop a Fluid Control Handbook to aid the system designer.

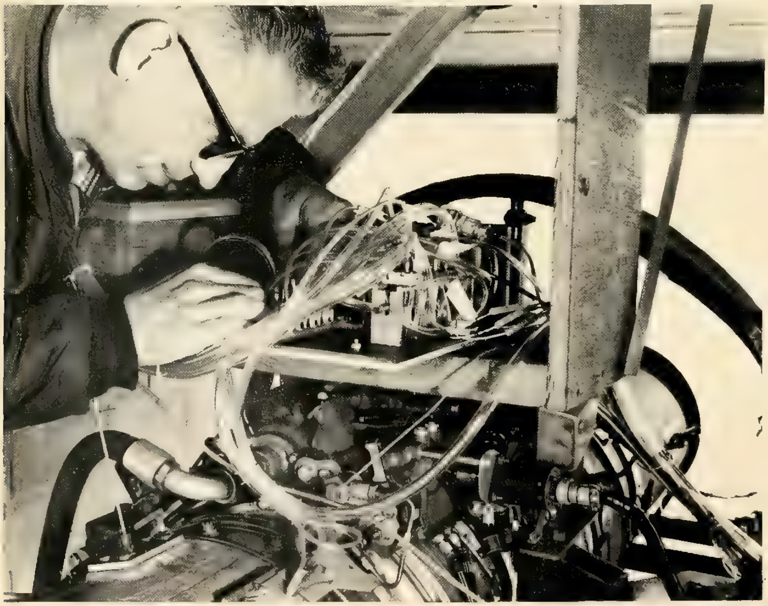
In addition to these broad studies NASA, primarily through MSFC and Lewis, already is engaged in a number of component development and early system studies with several firms. Also, space agency scientists told Missiles and Rockets that several new fluidic systems programs probably will be started in the coming fiscal year.

A run-down of the NASA effort follows.

Marshall Space Flight Center

MSFC's major interest in fluid systems, being pursued in its Astrionics Laboratory, relates primarily to their usefulness in various booster-engine control systems. However, some of the broad technology studies being carried out for MSFC may eventually feed future developments in the fields of guidance systems, on-board fluid computers, and sensors such as fluid gyros and accelerometers.

PURE-FLUID control system for jet engine shown under test at Honeywell Aeronautical Div. flight operations department in Minneapolis. System is being developed under contract to Air Force's Aeronautical Systems Div.



MSFC's major contractual effort to date has been the multi-phase GE study. The first phase of this involved a state-of-the-art survey; the second phase, a study of the most promising applications of fluid amplifier devices for NASA; the third, an analysis of the so-called "missing links," or weak areas in the new technology which could, if developed, open up new applications; and the fourth phase, just completed, an attempt to establish reliability estimates for various classes of devices (the problem of gathering reliability data on proprietary and difficult to test components is one of the most perplexing problems of fluid systems technology).

The fifth phase, now reportedly being negotiated, will look into some of the advanced control system applications, and could be very influential in determining future NASA support for fluid computing systems, guidance systems, and possibly advanced control systems for large boosters with nuclear stages.

The Sperry-Utah analytical work, which MSFC scientists also cite as being "most productive," included an investigation of the feasibility of a fluid-control subsystem for a hybrid thrust-vector-control servo system.

The Univac Div. of Sperry Rand has just completed an MSFC contract calling for development of multi-state fluidic logic elements to form a digital adder. Evaluations with this component are expected to aid further in NASA's decision regarding expanded fluid computer developments.

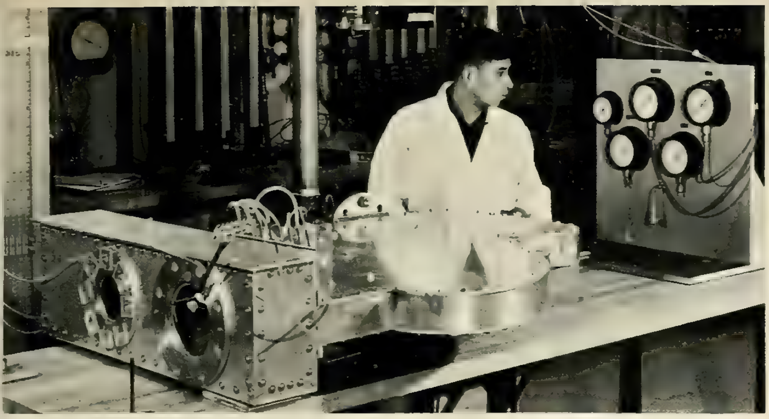
Bendix Products Aerospace Div., which recently completed an MSFC contract exploring development of a pneumatic actuator for gimbaling a large *Saturn*-class engine, is now working under NASA funding at use of fluid amplifiers for damping purposes in a fluidic servo system.

- **Possible projects**—Among the new programs that MSFC scientists have under consideration are:

—*Propellant Utilization Systems*—Use of a working fluid within an engine system to operate a fluid control system which would in turn control the ratio of fuel and oxidizer delivered to the engine.

—*Variable-Thrust Engine Systems*—Similar to the propellant utilization system, except that engine thrust rather than fuel/oxidizer ratios would be controlled.

—*Secondary Injection System*—Actually a form of thrust-vector-control which would seek to avoid engine gimbaling. NASA hopes to develop an all fluidic system, including sensors and a



GIANNINI double-leg-elbow amplifier recently delivered to NASA's Lewis Research Center. Unit is one of the largest amplifiers ever developed.

nozzle control device, although it admits it does not yet have an application for this.

Among other areas likely to get future MSFC attention and funding are new fluid sensors, including rate gyros and accelerometers, and studies of the complex interface problems between fluid, electrical, and mechanical devices. MSFC already has asked for bids for a hybrid servo valve development that would be a minimum-moving-part system with an electrical interface. An award is expected late in March. Bendix and GE are now working under separate NASA contracts which should lay some of the groundwork for this new effort.

Also under MSFC consideration is use of fluid-control systems for recovery of large booster stages—should such a program ever appear feasible.

MSFC also will expand its fluid laboratory in the next few months, adding new instrumentation such as hot wire anemometers, pressure transducers, and flow-rate measurement devices.

Lewis Research Center

The NASA-Lewis effort is basically aimed at improving the reliability of advanced propulsion system actuators, particularly for nuclear systems, by using fluidic systems wherever feasible to replace electronics. Most of the effort is sponsored by the Nuclear Rocket Dynamics and Controls Branch.

In the nuclear rocket area, Lewis has three major efforts under way, all with divisions of Bendix Corp., with a total contract value of about $260,000.

Bendix Research Labs is developing a pneumatic no-moving-part fluid servo valve which may replace the electromechanical assembly used to drive the control-drum actuator for the NERVA engine. The Research Lab also has a smaller contract for a state-of-the-art fluidic interaction servo valve design and development effort.

The firm's Aerospace Products Div. is being funded to develop an advanced actuator motor which would work with fluid systems, using moving parts but removing the electrical components.

Bendix Research also has another important NASA-Lewis effort involving development of an all-fluid amplifier for liquid-rocket applications, primarily directed at thrust-vector-control systems. Bendix will do analytical design and some experimental testing.

In addition, NASA-Lewis has in hand a just-delivered, no-moving-part proportional fluid amplifier. The 54 x 38 x 11-in. double-leg-elbow amplifier, developed by the Astromechanics Research Div. of Giannini Controls Corp. under a $20,000 NASA contract, will be used by NASA as a diverter valve for bypass flow control of a turbo-generator in lab studies.

In other programs, NASA-Lewis has supported a continuing grant to MIT to study stability criteria for interconnecting fluid devices; and has also just completed a small effort with GE on a feasibility study for a pneumatic position servo unit.

The Center's in-house efforts currently are aimed at optimization of a bi-stable fluid jet amplifier, which it hopes to report on soon, and an effort to map the characteristics of vortex valves, hoping to optimize such parameters as the ratio of chamber diameter to outlet orifice diameter.

Langley & FRC

The fluid systems work being carried on in the Instrument Research Div. at Langley and the Research Div. at FRC, though small and largely in-house, is in areas which, if some of the so-called missing links of fluid system design are filled in, could become major focal points of future development.

Both of these centers are concerned with flight-control systems. FRC work is mostly centered on piloted-aircraft flight control; Langley work is almost exclusively devoted to satellite control applications. In both areas, however, there is considerable interest in expanding the degree of fluid control into the sensor area or in interfacing with conventional sensors, such as radar.

NASA officials told M/R that support for out-of-house effort at both centers could be expected within the next few months.

At FRC, studies of light-aircraft fluid-control systems are expected to be initiated. At Langley, scientists see component development programs getting started for some of the items designers view as necessary for the beginnings of an all-fluid sensor-to-control-system network. Fluid actuators and analog-to-digital converters are expected to be early efforts; another may be a study of the requirements for a fluid computer system. Scientists point out that this study would not be for development of such a computer but to define its required capabilities.

Possibly later in FY'66, NASA scientists see initiation of some new sensor development support and studies of momentum-exchange techniques applicable to spacecraft stabilization and control. Further along, scientists—admittedly "brainstorming"—see the possibility of adaptive fluid control elements operating with a fluid computer.

AEC

Looking over NASA's shoulder in the development of fluid systems is the Atomic Energy Commission. While the AEC has no out-of-house effort, at least in non-military applications, the commission is very much interested in keeping abreast of the NASA work, particularly that going on at NASA-Lewis relating to nuclear control devices.

AEC scientists told M/R it is likely that the commission will spend some funds in this area in the future, possibly in adapting off-the-shelf items to specific requirements or perhaps for development of special transducers. As an example, AEC scientists told M/R, the commission would be interested in a high-temperature liquid-metal device, since this might constitute the working fluid in future AEC SNAP-type programs.

Officials also told M/R they see little application for these devices in civilian powerplant operation, but do see potential in some of the deep-space or lunar-base space programs, where environmental considerations and improvements in packaging density could make them attractive. ■

Special Report: FLUIDICS

Five Firms Top Field in Achievement

Early in-house investments pay off in securing military support; a profile of 25 leading organizations' efforts

THE FIELD OF FLUIDICS in the U.S. today appears to be led by five companies—Bendix, Bowles Engineering, General Electric, Honeywell and Sperry Rand. Each holds a top-ranking position for different reasons.

Bendix has by far the largest staff and greatest number of different contracts, but it probably is second to Honeywell in total and annual dollar volume. Both of these firms began their efforts in the 1960-61 period, invested heavily with company funds and—as a result of their recognition of the potential of the field—secured early and significant military support.

General Electric and Sperry Rand have followed with broadening in-house efforts. Each has shown a tendency to parallel military and NASA systems R&D with an equally strong industrial/consumer product-development program. The vigor with which Sperry has filed patent disclosures within the past year is indicative of the breadth of its attack on the technology and its determination to secure a strong market position for the future. The GE approach is similar.

Bowles offers a different potential. Small compared to the four industrial powers, it nevertheless is growing rapidly because of its concentration on fluidics technology, its strong patent situation and the fact that, lacking in any large production capability, it offers no real threat to the other contenders.

Thus, considering only the latter attribute, all the rest in the industry are potential Bowles clients for consultation and specialized R&D services.

The company's future growth rate, however, probably will hang on its ability to develop and successfully market specialized proprietary product lines in the industrial and consumer fields.

• **Representative listing**—In the following pages, M/R editors have summarized the capabilities and interests of more than 25 U.S. organizations in the fluidics field. Actually, nearly 300 firms are believed to be active in varying degress in fluidic technology; in general, however, their contributions to the field have been minimal.

Most of these tend to fall into one of three groups: (1) monitoring fluidics technology to keep abreast of the state of the art; (2) just beginning to invest in fluidics research; or (3) investing either in in-house or out-of-house development of one or two basic devices for highly specialized applications.

The top five fluidics firms lead the summaries below. The order of listing of those that follow does not indicate their market positions.

Bendix Corp.

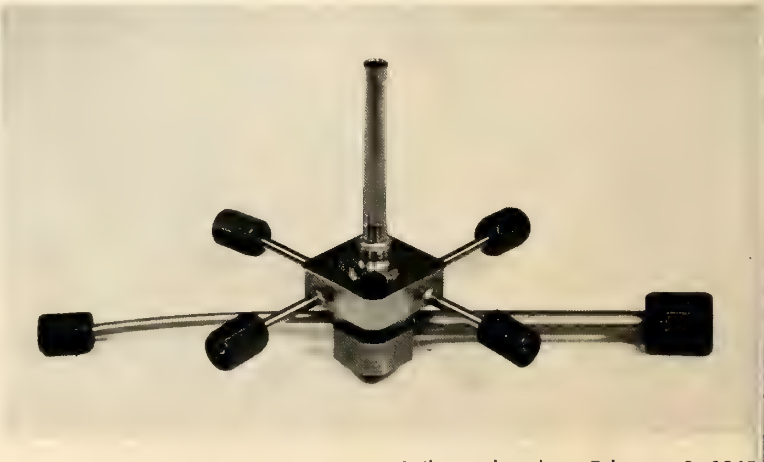
Officials disclosed that the firm is concentrating on fluidic closed-loop control systems, including sensors, feedback and compensation networks, computation, power amplification actuators and power supplies.

Bendix has made maximum use of the jet-on-jet devices pioneered at Harry Diamond Lab and also has developed independently a broad line of components, including vortex flow sensors, amplifiers, and power valves. Operational circuits developed generally include a mix of both the vortex and jet-on-jet devices, and either type may be used in proportional or digital applications.

The firm, primarily through activities at the Research Laboratories Div., Southfield, Mich., and the Bendix Products Aerospace Div., South Bend, Ind., has been contracted for about $1.5 million in paid R&D in fluid state technology thus far, much of it in recent months, which has boosted the corporation's efforts in this field to a position close to the top. The Sheffield Corp., Dayton, Ohio, a Bendix subsidiary, is also seeking applications of fluidics for machine tools and for gaging. Roughly 120 Bendix personnel are now engaged in fluidics R&D and production.

Bendix is performing R&D work, either company-funded or government-funded under NASA or military contracts, in the following control areas: nuclear reactors, fuel cells, aircraft and missile flight controls, gas turbines, process control, machine-tool numerical control, rocket engine thrust vectoring, and inertial navigation systems.

VORTEX AMPLIFIER allows amplification of varying pressure-flow signals by the modulation of a vortex flow pattern. Model shown, developed by Bendix Corp. Research Laboratories, has four discrete tangential inputs, providing the functions of addition and subtraction as well as amplification. Other tubes visible provide for source power input, signal output and venting.



Officials point out that technology is already plagued by some of the basic limitations inherent in electronic systems: S/N ratio, impedance matching, and amplifier oscillation and power supply regulation.

Temperature and radiation environment considerations, however, will still make these devices appealing, they report, even though frequency response or clock speeds will never achieve equality with electronic systems. They point out that some fluidic circuits have been operated as high as 1-10 kc, depending upon circuit complexity, and that some individual components, such as oscillators, have operated as high as 150 kc. Scientists at Bendix expect steady increases in the upper frequency limit.

Bowles Engineering Corp.
Silver Spring, Md.

Begun as a one-man, part-time operation in 1961 by Dr. R. E. Bowles, and now employing about 40 persons, Bowles Engineering Corp. is an R&D and manufacturing firm specializing in fluidic systems and components. It has concentrated on development of a broad line of basic "pure-fluid" components for systems application in the military, industrial and consumer markets.

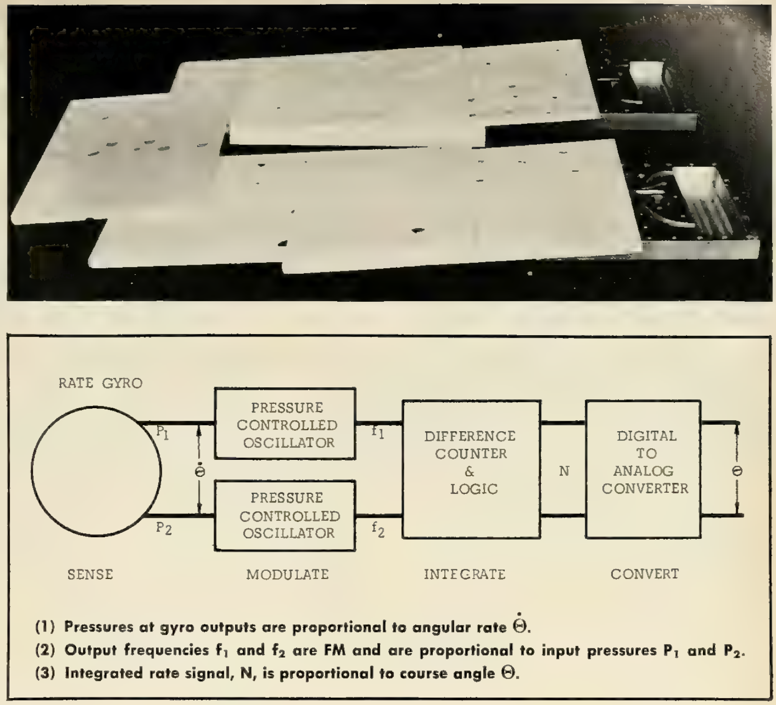
It also is in the unique position of holding many of the basic patents involving fluid amplifications, since it has purchased all the original patents registered under Bowles-Warren-Horton. The three inventors enjoy a royalty arrangement and Bowles Engineering, upon approval by the corporation, will license any reputable company to unrestricted use of the patents.

Restricted licenses for use of patents originated by BEC also can be obtained, but these are sold only with careful regard to the company's preferred technological/market position.

- **Market position**—BEC total sales in fluidics for 1964 exceeded $620,000. This was double the previous year's sales. No breakdown of sales is available, but it is known that the company's R&D effort is heavily weighted toward the military—primarily with Navy support—and its manufacturing or product sales are industrially weighted. Reportedly, Bowles' military sales exceed its industrial revenues by 4:1.

Possibly the largest Bowles effort today is a torpedo fluidic control system under development for the Bureau of Naval Weapons. A continuing, long-term project, it has a funding level of about $200,000 a year.

A very large fluidic control system that would permit a submarine to hover, and might also serve as a secondary propulsion system, is being developed by Bowles under a $50,000 Bureau of Ships contract. Used in pairs, or possibly two pairs, each fluid amplifier will develop 2,000 lbs. of thrust controlled by water jets.


RATE GYRO
P_1
P_2
$\dot{\Theta}$
PRESSURE CONTROLLED OSCILLATOR
PRESSURE CONTROLLED OSCILLATOR
f_1
f_2
DIFFERENCE COUNTER & LOGIC
N
DIGITAL TO ANALOG CONVERTER
Θ
SENSE
MODULATE
INTEGRATE
CONVERT

(1) **Pressures at gyro outputs are proportional to angular rate $\dot{\Theta}$.**

(2) **Output frequencies f_1 and f_2 are FM and are proportional to input pressures P_1 and P_2.**

(3) **Integrated rate signal, N, is proportional to course angle Θ.**

FLUIDIC COURSE CONTROL system using FM techniques is being developed by Bowles Engineering Corp. for missile/torpedo applications. TOP: The pressure-controlled oscillators are brass; the other circuit components are plastic, measuring 4 x 7 in. BOTTOM: System block diagram.

Now being evaluated by the Marine Engineering Laboratories, the system may someday find use in all *Polaris*-type submarines.

Two other BuShips contracts, totaling well over $100,000 each, have been awarded BEC in the past. One, for a boiler control system, is still in effect.

Under another BuWeps contract, valued at $26,000, Bowles is studying fluidic systems applications for in-flight refueling, fire control and other aircraft operation. Awarded in May, 1964, this study will terminate soon.

For the Harry Diamond Laboratories (see p. 30), Bowles is developing fluidic analog-computer circuits under a $15,000 contract. These are all low-noise, basic functional-logic elements.

- **Changing emphasis**—Bowles cut its teeth as a young firm on military R&D contracts. With time and experience, B.E.C. broadened its product base and began finding an industrial market in the area of valves, control equipment and—by 1963—analog circuits. The firm's first consumer product, developed in 1964, is expected to be marketed this year. Its nature has not been disclosed.

The firm is pressing to improve its military-to-government sales ratio, but one of its greatest assets—product secrecy—may also be its greatest deterrent. Dr. Bowles says his firm has sold many fluidic components to manufacturers for integration into other products, and has developed many process and production control devices for industrial customers. Yet, Bowles declared, with but one exception all firms have included a secrecy stipulation in their purchase agreements.

The principal reason, according to Bowles, is that through employment of fluidic systems users believe they have obtained a preferred marketing position or enhanced production capability vis-à-vis their competitors. Secrecy helps maintain this competitive edge, but does little to promote Bowles' achievements.

- **Device development**—Bowles has employed nearly all the conventional fluidic component materials—including glass, plastics and various metals.

As a development tool, designers at BEC employ the Optiform technique (a Dupont laminate consisting of 0.040-in.-deep photopolymer with an aluminum plate backing originally developed for the printing industry) to work out and test circuit performance. The firm, using a proprietary method not revealed to M/R, can then go directly to production devices using more appropriate materials. Production devices may or may not be the same size as the Optiform prototype, said Bowles.

In general, BEC engineers asserted,

plastics continue to offer many practical advantages from the standpoint of cost and environment, particularly when size is not a limiting requirement.

The firm is concentrating now on development of analog circuits providing FM signals as a means of limiting degrading noise. Since most noise is systematic, it can be integrated to zero, said Bowles Chief Engineer E. M. Dexter.

To perform this function, Bowles is developing a fluidic pressure control oscillator. The present laboratory test device operates at 75-150 cps, but others have been built with frequencies up to 700 cps.

Another device in final development is a pressure band gate for pneumatic gaging. It will provide an output from 3-15 psi, without saturation, from very low pressure inputs.

Typical Bowles catalog laboratory-breadboard devices include an amplifier/inverter, two- and three-input OR/NOR logic elements, two- and four-input flip-flops, single- and six-stage binary counters, and a three-stage analog amplifier. Prices vary from $40-110.

General Electric Co.

GE has several operating departments now taking part in fluidic systems developments.

The firm is still at work on a multiphase NASA study contract aimed at helping the space agency pursue a directed program of R&D in this field (see page 32). In addition to the study portions, the firm reports it has also received NASA funding for development of the two key areas it recommended in the report as being most immediately applicable to NASA missions—a pneumatic analog amplifier for use in a hybrid servovalve system for gimbaling rocket engines (Bendix also has a similar contract), and a digital integrator that GE sees as the key to several future space computation possibilties.

The firm's Flight Propulsion Div. in Ohio is also under contract to the Air Force at Wright Patterson AFB for development of a fluidic jet-engine control system. This system is associated with an advanced engine development, still on the drawing board according to informants, and involves fuel speed and temperature loops and a pressure ratio control. All pneumatic analog-type elements are used including amplifiers, oscillators, phase shifting networks and resonators. The computation type devices are reportedly of GE design, with some of the associated sensors based on earlier Harry Diamond Lab designs.

The firm's Fitchburg, Mass. operation is developing speed controls for steam-turbine generators for the Navy.

For the Army, the firm's Missile and Armament Div., Burlington, Vermont, is at work on a digital fuse timer for the Picatinny Arsenal. Now in the second phase for this contract, GE says it is working toward miniaturizing the device and reducing power consumption. It has experienced some success, producing a design that now involves "only a few cubic inches of fluid logic," according to one company spokesman.

SUMMARY OF HONEYWELL SYSTEMS DEVELOPMENT PROGRESS THROUGH 1964

SYSTEM	GOAL OF PROGRAM	SYSTEM FUNCTION	COMPONENTS INVOLVED	STATUS
ROCKET AND TORPEDO CONTROL DEMONSTRATOR (FLUID-AIR)	MATCH VORTEX RATE SENSOR AND AMPLIFIERS AND PRODUCE FORCE OUTPUT CAPABLE OF CONTROLLING MODEL	SENSE MODEL MOTION AND PRODUCE FORCE TO OPPOSE MOTION. STOP SPINNING MODEL WHEN CONTROL SYSTEM TUNED ON	VORTEX RATE SENSOR PROPORTIONAL AMPLIFIER, 3-STAGE BISTABLE CASCADE, REACTION JETS, GAS SUPPLY.	COMPLETED 1961. STILL OPERABLE.
"CONTROL DEVICE X" (FLUID-HYDRAULIC OIL)	PROVIDE HYDRAULIC RATE DAMPER AND SHOW THAT IT COULD BE USED TO STABILIZE A SIMULATED VEHICLE	SIMULATE SERVO AND AIRCRAFT DYNAMICS, DRIVE WOBBLE TABLE WITH OUTPUT REPRESENTING VEHICLE ATTITUDE, SENSE TABLE MOTION AND CLOSE LOOP TO COMPUTER BY FLUID SYSTEM	VORTEX RATE SENSOR, BUFFER AMPLIFIER, BISTABLE AMPLIFIER CASCADE, FLUID TO ELECTRICAL SIGNAL TRANSDUCER, ANALOG COMPUTER, WOBBLE TABLE, HYDRAULIC SUPPLY	COMPLETED 1962.
HYDRAULIC DEMONSTRATOR	PROVIDE PROPORTIONAL FLUID CONTROLLED HYDRAULIC SERVO WITH FORCE OUTPUT SUFFICIENT TO OPERATE HELICOPTER CONTROLS	USE FLUID AMPLIFIER AS CONTROL VALVE FOR PISTON TYPE SERVO IN A POSITIONAL SERVO LOOP	MANUAL COMMAND INPUT AND SERVO POSITION FEEDBACK SUMMED IN 2-STAGE FLUID AMPLIFIER UTILIZING VARIABLE GAIN FEEDBACK TO CONTROL OVER-ALL SERVO LOOP GAIN. PISTON CYLINDER TYPE ACTUATOR	COMPLETED 1963.
RATE STABILIZATION SYSTEM FOR LIGHT AIRCRAFT (USING CESSNA 310 AS TEST VEHICLE)	DEMONSTRATE THAT A SIMPLE, PROPORTIONAL RATE DAMPER CAN STABILIZE AN AIRCRAFT IN FLIGHT	SENSE AIRCRAFT PITCH MOTION DRIVE PNEUMATIC SERVOS TO MOVE AIRCRAFT CONTROL SURFACES, ACCEPT MANUAL INPUT COMMANDS	VORTEX RATE SENSOR, PROPORTIONAL AMPLIFIER CASCADES MANUAL INPUT, PNEUMATIC SERVO.	COMPLETED AND FLIGHT TESTED IN SUMMER 1963. STILL OPERABLE
FLUID RATE SWITCH DEMONSTRATOR	DEMONSTRATE THAT A SIMPLE FLUID SYSTEM CAN ARM A MISSILE WHEN A PRE-SET SPIN RATE HAS BEEN ATTAINED	SENSE SPIN RATE, ACTUATE A PRESSURE SWITCH DIRECTLY FROM VORTEX RATE SENSOR OUTPUT, CLOSE ELECTRICAL CONTACTS WHEN PRE-SET PRESSURE LEVEL OBTAINED	VORTEX RATE SENSOR, PRESSURE SWITCH, HAND OPERATED RATE TABLE, LIGHT, SMALL COMPRESSOR.	COMPLETE END OF 1963.
AIRCRAFT "WING LEVELER"	DEMONSTRATE THAT FLUID RATE DAMPER CAN STABILIZE AN AIRCRAFT IN THE ROLL AXIS.	SENSE AIRCRAFT YAW MOTION, DRIVE PNEUMATIC SERVOS TO MOVE AILERON CONTROL SURFACES.	VORTEX RATE SENSOR, MINIATURE PROPORTIONAL AMPLIFIER CASCADES, PNEUMATIC SERVOS.	FLIGHT TESTED SUCCESSFULLY IN AUGUST 1964.
ANALOG-TO-DIGITAL CONVERTER	DEMONSTRATE FEASIBILITY OF CONVERTING ANALOG SIGNALS TO DIGITAL SIGNALS AT A USEFUL SPEED AND ACCURACY	ACCEPT ANALOG SIGNALS FROM FLUID DEVICES, CONVERT TO BINARY, DIGITAL SIGNALS ACCURATELY REPRESENTING CONTINUOUSLY CHANGING INPUT	OSCILLATOR, COMPARATOR, GATES, DIGITAL-TO-ANALOG CONVERTER, UP-DOWN BINARY COUNTER	DEMONSTRATED 1964.
BINARY AND DECIMAL COUNTERS	DEMONSTRATE ABILITY OF FLUID DEVICES TO COUNT PULSES OVER A WIDE INPUT FREQUENCY RANGE.	ACCEPT, COUNT, AND REGISTER NUMBER OF INPUT PULSES RECEIVED, PROVIDE FLUID OUTPUT SIGNAL WHICH INDICATES NUMBER OF PULSES RECEIVED	BISTABLE AMPLIFIER ELEMENTS, OR-NOR ELEMENTS, COUNTER ELEMENTS	DEMONSTRATED 1964.
SEQUENCING DEVICES (FOUR-BUTTON LOCK)	DEMONSTRATES THAT COMPUTER LOGIC OPERATIONS CAN BE PERFORMED WITH FLUID ELEMENTS	ACCEPT PULSE SIGNAL FROM FOUR SOURCES, PROVIDE FLUID OUTPUT ONLY WHEN A PRESET NUMBER OF SIGNALS IS RECEIVED IN A PRE-SET SEQUENCE.	BISTABLE ELEMENTS OR-NOR ELEMENTS	DEMONSTRATED 1964
DIGITAL SHIFT REGISTER	DEMONSTRATES THAT FLUID ELEMENTS CAN BE USED TO PERFORM ONE OF THE COMPLICATED OPERATIONS REQUIRED IN A DIGITAL COMPUTER	SHIFT FLUID SIGNALS REPRESENTING A BINARY NUMBER IN A PARTICULAR 10-DIGIT REGISTER ONE OR MORE DIGITAL PLACES THE NUMBER OF PLACES BEING PROPORTIONAL TO THE NUMBER OF PULSES RECEIVED	BISTABLE ELEMENTS	DEMONSTRATED 1964
ANALOG ROTATION SPEED CONTROL	DEMONSTRATE THAT A SIMPLE CLOSED-LOOP FLUID SYSTEM CAN CONTROL ROTATION SPEED TO A DESIRED SET VALUE	SENSE TURBINE WHEEL SPEED, COMPARE TH S SPEED SIGNAL WITH A SET POINT SIGNAL AND DRIVE THRUST JETS WITH AMPLIFIED ERROR SIGNAL TO CONTROL WHEEL SPEED	TURBINE WHEEL, SPEED SENSOR PROBE, 7-STAGE PROPORTIONAL AMPLIFIER CASCADE, VISUAL SPEED METER, FLUID POTENTIOMETER THRUST JETS.	DEMONSTRATED IN JULY 1964.
TEST AND INSTRUMENTATION MISSILE STABILIZATION SYSTEM	DEMONSTRATE, BY FLIGHT TEST, A STABILIZATION SYSTEM FOR A SMALL MISSILE	STABILIZE AND CONTROL MISSILE ABOUT ITS ROLL AXIS DURING FLIGHT.	VORTEXT RATE SENSOR BISTABLE AND PROPORTIONAL AMPLIFIER CASCADES, 10-SEC TIME CONSTANT, SUPERSONIC REACTION JETS, COLD GAS POWER SUPPLY	FLIGHT TESTED SUCCESSFULLY SEPTEMBER 1964.
TURBOJET ENGINE CONTROL SYSTEM	DEVELOP CONCEPT AND COMPONENTS AND DEMONSTRATE A TURBOJET ENGINE CONTROL SYSTEM USING THE J-85 ENGINE AS A VEHICLE	CONTINUOUSLY MEASURE DETERMINANTS OF FUEL FLOW TO ENGINE, OPTIMIZE VALUES UNDER ALL OPERATING CONDITIONS BY A CLOSED LOOP SYSTEM	PRESSURE AND DIFFERENTIAL PRESSURE SENSORS, TEMPERATURE SENSORS, PROPORTIONAL AND BISTABLE AMPLIFIERS, ANALOG AND DIGITAL ENGINE SPEED SENSORS, TURBINE COMPRESSOR STALL SENSORS, TEMPERATURE LIMITING SUB-SYSTEM.	IN PROCESS. TEST RUNS IN MID 1964.
ACCELEROMETER A/D CONVERTER AND FLUID COUNTER DEMONSTRATOR	SHOW THAT FLUID DEVICES CAN MEASURE SMALL ACCELERATIONS, AND PROVIDE A BINARY READOUT CORRESPONDING TO THE MEASURED ACCELERATION	SENSE SMALL ACCELERATION, PROVIDE AMPLIFIED ANALOG SIGNAL, TRANSFORM SIGNAL TO DIGITAL FORM, OPERATE BINARY COUNTER AND PROVIDE DIGITAL READOUT	ACCELEROMETER, MINIATURE PROPORTIONAL AMPLIFIER CASCADE, BISTABLE AMPLIFIERS, OSCILLATORS, OR-NOR ELEMENTS	DEMONSTRATED SEPTEMBER 1964
F101 YAW DAMPER	SHOW THAT A FLUID SYSTEM OPERATING FROM ENGINE BLEED AIR CAN CONTROL A HIGH PERFORMANCE AIRCRAFT	SENSE YAW RATE, AMPLIFY AND CONVERT OUTPUT TO ELECTRICAL SIGNAL AND CONTROL HYDRAULIC ACTUATOR	VORTEX RATE SENSOR, PROPORTIONAL AMPLIFIER CASCADE, FLUID TO ELECTRIC TRANSDUCER.	DEMONSTRATED OCTOBER 1964.

The re-settable timer, which works off ram air and whose development is being directed primarily toward artillery ammunition applications, includes a fluid oscillator for clock functions and a fluid frequency divider and counter. The current design reportedly involves shrinking orifice size to about 10 mils, which GE designers see as a very workable and useful size obtainable without too much difficulty. This view to miniaturization is acknowledged by many within the industry. GE, as some others believe, sees no real advantage in pressing for significantly smaller orifice sizes.

The firm's efforts on behalf of NASA in the reliability study area have also yielded some highly auspicious data thus far. GE scientists told M/R that fluid digital elements, made into shift registers and exercised at very high clock rates in an extended test program, have exhibited individual values of more than 10^{10} switches without failure.

Honeywell, Inc.
Minneapolis, Minn.

Out of basic research in pneumatic and hydraulic control systems being performed by Honeywell's Aeronautical Div. in late 1959-1960, a formal R&D program in fluidics evolved in 1961.

Early the next year, the Aero division was awarded a two-year $100,000 contract to study and improve fluidic vortex rate sensors for the Air Force Systems Command.

Other smaller contracts from both the Army and Air Force followed, and in July, 1963, Honeywell won a $600,000 14-month contract to perform a comprehensive applied research study of the application of fluidics to inertial navigation systems and associated components.

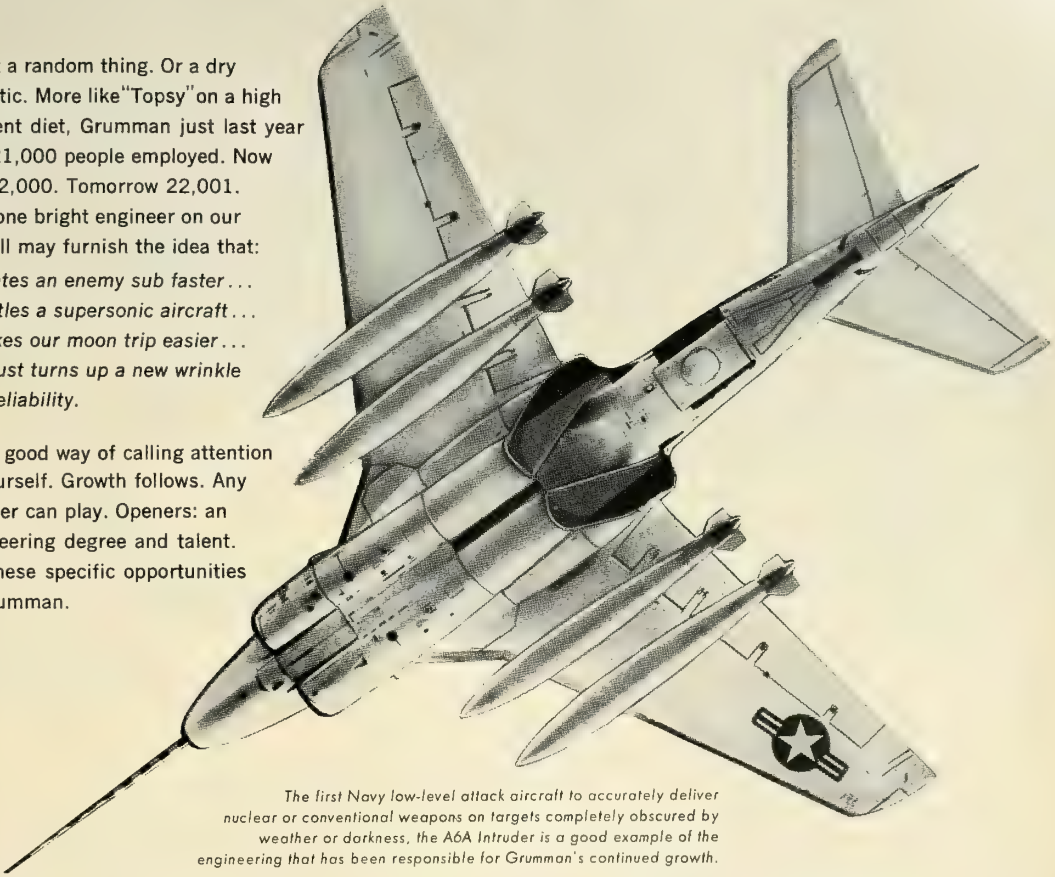
In a concurrent program, awarded in December, 1963, Honeywell began a $420,000 contract for the Air Force Aero Propulsion Lab, Wright-Patterson AFB, to demonstrate feasibility of fluidic controls for a J85 jet engine. This initial contract, ending in March this year, was to demonstrate effective

GROWTH AT GRUMMAN

is not a random thing. Or a dry statistic. More like "Topsy" on a high nutrient diet, Grumman just last year had 21,000 people employed. Now it's 22,000. Tomorrow 22,001. Just one bright engineer on our payroll may furnish the idea that:

locates an enemy sub faster . . .
gentles a supersonic aircraft . . .
makes our moon trip easier . . .
or just turns up a new wrinkle in reliability.

It's a good way of calling attention to yourself. Growth follows. Any number can play. Openers: an engineering degree and talent. See these specific opportunities at Grumman.



The first Navy low-level attack aircraft to accurately deliver nuclear or conventional weapons on targets completely obscured by weather or darkness, the A6A Intruder is a good example of the engineering that has been responsible for Grumman's continued growth.

Rocket Propulsion Engineers—Engineering degree plus several years experience with liquid rockets. Involves challenging duties in the area of steady-state, transient, and mal-function performance analysis as applied to manned space vehicles. Both junior and senior positions available.

Reaction Control System Engineer—Technical specialist to perform analysis of small pulsed rocket engines and pressure fed propellant systems. A firm background in liquid rocket engines desirable.

Senior Thermodynamicist—Advanced degree with minimum of 5 years experience performing heat transfer analysis. Specific opportunities in aerodynamic and re-entry heating, structural temperature determination and heat transfer phenomena in propulsion systems.

Heat Transfer Engineer—BSME to work on thermal design of space electronic systems. Must be able to perform detailed analyses of electronic equipment cooling requirements and direct necessary thermal test programs.

Thermal Control Engineer—Engineer with experience in handling space vehicle temperature control system analysis. Should have background in radiative heat exchange and thermal coatings as applied to passive and active temperature control systems.

Gas Dynamics Engineer—BS in AE or ME with applicable experience, to be responsible for one or more of the following: Internal Aerodynamics, Ducted Fans, VTOL, Thrust Deflection Systems, Compressible Fluid Flow, Shock Wave and Boundary Layer Theory, Inlet, Nozzle and Exhaust System Flow Analysis; Method of Characteristics; Windtunnel and Duct Lab Testing.

System Reliability Engineers — With strong mathematical background to initiate and conduct system reliability studies. Studies include: Mission analysis to optimize mission success, reliability apportionment and trade-offs. BS in engineering physics or mathematics with at least 3 years' systems and/or reliability experience.

Site Activation Engineers—BS or equivalent with 2 or more years experience in installation & validation of check-out and maintenance equipment for spacecraft systems. Positions encompass planning & establishment of facilities requirements, procedures & specifications, check-out & validations of automatic test equipment & ground support equipment at field sites in Texas & Florida. Special experience areas include: Electrical & Electronic Systems, Cryogenic & Hypergolic Fluids Handling, Proposition Test Facilities; Mechanical Systems.

Pre-Launch Check-Out Planning and Analysis Engineers—BS in AE or ME or Chemical Engineering or equivalent with more than 2 years experience in planning, developing & maintaining check-out plans & manuals for spacecraft systems pre-launch tests. Work will lead from the planning stage through the conduct of the tests in field sites in Texas & Florida. Particular engineering experience areas include: Propulsion systems, environmental control systems, structural & mechanical systems, Pyrotechnic device systems, cryogenic & hypergolic handling systems, & automatic checkout equipment applications.

Spacecraft Mission Planning Engineers—BS or advanced degree with applicable experience in mission planning & flight test analysis of manned spacecraft. Areas of particular interest are: determination of in-flight & ground test requirements, trajectory analysis, determination of flight constaints & in-flight test phases, time line analysis of spacecraft programs. Knowledge of propulsion, environmental control, fluids & mechanical systems with spacecraft applications are desired. Duties will include preparation of test plans, presentation of flight results & co-ordination with NASA agencies.

Guidance Dynamicists — BS or MS in AE, EE, or Applied Mechanics with a minimum of 2 years' experience in the analysis of guidance systems for spacecraft, will analyze and evaluate functional configurations and dynamic characteristics of radar, IR optical and inertial guidance loops; signal processing and error analysis. Background in sampled data and nonlinear controls systems analysis techniques is desirable.

To arrange an immediate interview,
SEND RESUME to
Mr. P. M. Van Putten,
Manager Engineering Employment,
Dept. GR 86

GRUMMAN
AIRCRAFT ENGINEERING CORPORATION
Bethpage • Long Island • New York

(An Equal Opportunity Employer)

Circle No. 7 on Subscriber Service Card

engine control under sea level conditions. Follow-on contracts are expected to demonstrate feasibility under flight conditions.

Honeywell estimates that since 1961 it has invested nearly $1.5 million to build a fluidics capability. Government-funded contracts through Fiscal Year 1964 totaled $2.5 million.

Over 50 scientists and engineers are employed in full-time fluidics developmen in three Honeywell divisions: the Military Products Group Research Lab (basic and applied research); the Aero Div. at both Minneapolis and St. Petersburg, Fla. (component and flight systems development); and the Ordnance Div. (weapon system applications).

Honeywell accomplishments in both fluidic component and system development have been impressive. Highlights of many of these are shown in the table on p. 40.

The launch last September of a prototype missile flight-control system using fluidic techniques was a marked success. The experimental system, which included a vortex rate sensor and proportional and bistable amplifier cascades, was employed to sense roll errors, stabilize and control a short-range test missile during a 10-sec. flight.

A programmed roll misalignment was corrected from 1,200 degrees to 100 degrees in 10 seconds of flight with damping to 7 degrees. Power gain through the cascaded amplifiers to the reaction-jet output, according to Honeywell, was 10^{15}.

(Refer also to Part II of this report, p. 32.)

Sperry Rand Corp.

Sperry Rand's efforts in fluidics are spread among five divisions and the firm's new research center in Massachusetts.

A major center of activity is the Sperry Utah Co. in Salt Lake City. In addition to the extensive NASA effort being supported at SUCO (see page 32), the company also has broad in-house development effort aimed at fluidic system application to short-range tactical missile guidance, an area where there is considerable optimism concerning practical application. Designers feel that required accuracies can be achieved with current technology and that reliability, environmental, and low production cost advantages can be realized.

At SUCO, major developmental emphasis is now on pure-fluid rate sensors and accelerometers for the missile guidance role. The rate sensors are reported to be vortex-type sensors and the accelerometer is said to be proceeding with a force-feedback design. Also under development is a new pressure regulator, in which NASA has shown interest.

SUCO is working with Sperry Gyroscope's Inertial Div. in Great Neck, N.Y., on development of fluid pickoffs capable of being mated with fluid rate sensors in the future.

The Great Neck division also is working with the Sperry Phoenix Co. on development of flight control systems for both commercial and military aircraft. Much of the development here is being accomplished using the impact-modulator type of proportional amplifiers developed by Johnson Service Co., through a licensing agreement. Sperry engineers say the amplifier exhibits very good isolation properties between stages.

The Inertial Div. has under development a hybrid type of fluid gyro, which does not involve vortex flow but operates basically using the inertial effects of a rotating fluid, and which uses electronic pickoffs. The group also has developed a fluid accelerometer.

For missile applications, Sperry Utah Co. designers, in general, see some hybridization evolving, at least initially. For example, for position sensing, a moving-part position gyro might be used with fluidic pickoffs, which in effect would substitute a mechanical-fluidic interface for a mechanical-electrical interface.

Vickers, Inc., another Sperry Rand division, is involved in fluidic systems, primarily in the power controls area, working on hot-gas valve developments, and digital-actuator interface problems.

The firm's Univac Div., which has had support from NASA, Harry Diamond Lab., and Sandia Corp. for fluidic efforts, is now engaged in refining the design and reducing the size and power requirements of fluidic digital computer systems. It demonstrated last October—an important first in the fluidic systems field when it operated an experimental general-purpose digital computer employing about 250 NOR-type switching elements. The demonstration system has four instructions and four words of memory, each four bits long.

Sperry officials also stress what they believe is a major contribution made to fluidic systems technology through work at the firm's Research Center in achieving numerical solutions to the Navier-Stokes equations, basic to fluidic systems design, for transient conditions. Much of this effort was accomplished as part of a NASA contract for analytical work (see page 35).

Consolidated Systems Corp.
Pomona, Calif.

With a strong background in the application of electronic logic and precision pneumatic systems, Consolidated Systems Corp. has an interest in fluidics as a possible marriage of the two technologies.

Its in-house effort so far has been primarily a study of published characteristics of fluid-logic devices as they might apply to the company's systems development. Experimental work has been carried out on relatively large fluidic flip-flops based on the Coanda effect and exploration of a new approach using phase change between a gas and liquid.

To help determine true market interest of the industry at the working level, CSC has developed a simple fluid logic demonstrator. This is being distributed by 16 field engineers, who report a generally favorable reaction to it.

The company has not sought study or hardware contracts in the past, but is now actively looking for such opportunities in the fluidics field.

Corning Glass Works
Bradford, Pa.

Directors of the Fluid Amplifier Dept. of Corning Glass Works' Electronics Div. see two distinct levels of opportunity opening up to component fabricators and suppliers in the fluidic circuits business, and they have expressed an intention to pursue both. The firm is directing its efforts at (1) refinement of fluidic component fabrication and production techniques in order to provide production services to systems designers with proprietary design circuits, and (2) provision of a standard line of basic fluidic devices for those systems firms which require only off-the-shelf type items for their particular requirements.

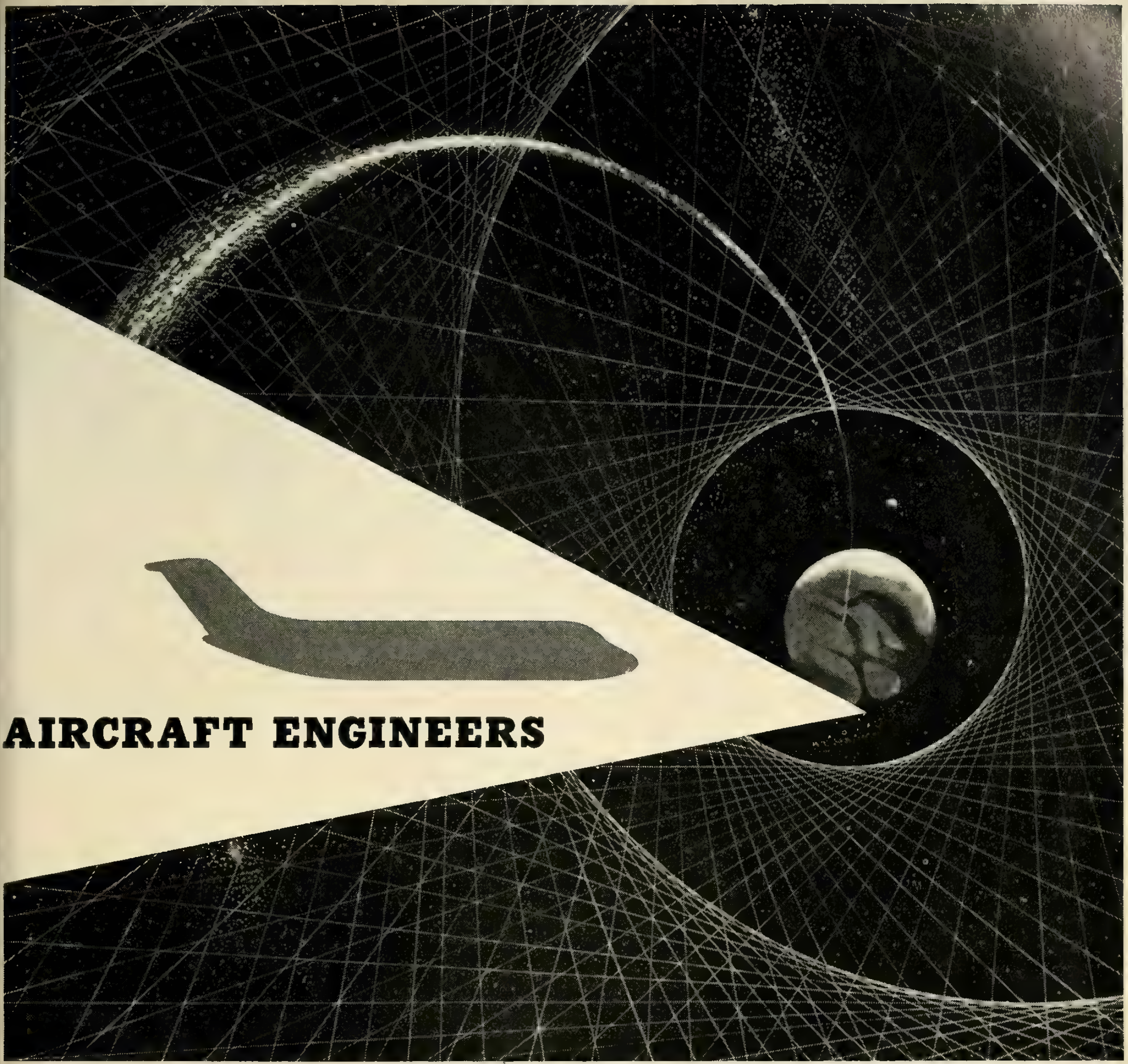
Corning's efforts in this field began in 1961 with a Harry Diamond Lab contract to study fluidic device fabrication methods, principally aimed at exploring the possibilities of etching high-precision flow channels for fluid circuitry in Corning's "Fotoceram" material.

The HDL contract with Corning is still continuing, but the firm has now added to its primary emphasis on fabrication with more R&D on proportional amplifier design.

In May, 1963, the firm made the decision to establish the Fluid Amplifier Dept., headed by Richard O'Brien, and reports that it is still increasing its investment in this operation. The firm, in addition to the HDL awards, has supplied devices to a number of the major fluid systems firms.

O'Brien, discussing progress in the fabrication area with M/R, pointed out how emphasis has shifted since initial work began at the firm from one of concern with accurate machinability and device aspect ratios, to one of internal circuit leakage and sealing problems, to the uppermost current concern for repeatable performance.

O'Brien sees this latter yardstick as the major and most reliable indicator of



We have a ten year backlog of exciting programs... and more coming!

Our expanding schedule includes a huge program on what will be the largest aircraft ever built, the jet C-5A. It encompasses bigger, longer-range versions of the DC-8 and DC-8F; military and business configurations of the twin-jet DC-9; advanced versions of the Navy A-4E attack airplane and its two-place training counterpart, the TA-4E; and advanced aircraft. And there are other programs we can't publicize at this time.

Right now we are urgently seeking aircraft engineers with BS or advanced degrees who have experience in any of the following: Aerodynamics; Stress Analysis; Load Analysis; Dynamic Analysis; Electrical Design; Structures Design; Power Plant—Thermo-Mechanical; Flight Test Instrumentation; Flight Test Data Analysis; Reliability; Advanced Systems Engineering. Openings include a number of senior positions.

For full information, please send resume to Mr. C. D. Carrico, Professional Employment, Douglas Aircraft Company, 3855 Lakewood Boulevard, Long Beach, California. An equal opportunity employer.

DOUGLAS AIRCRAFT GROUP

good process control by a manufacturer. "It is easy to get a bi-stable device to be bi-stable under certain conditions, but to make 150 of them is another story," he says.

Corning introduced its first line of standard breadboard-type fluidic components about a year ago, including a timer, counter, various AND, OR and NOR gates, and a proportional amplifier. Last month, the firm introduced additions to this line, including some higher power double-size nozzle proportional devices, bi-stable elements, additional gates, fluid resistors, and a new timer.

In the Corning fabrication technique, the firm's photosensitive glass is masked with a photograph of the desired channel pattern, exposed to ultraviolet light, and then chemically etched to the proper depths for the desired channels, chambers, ports, and interconnection holes. When layers are sealed by heat treatment, the glass is converted to a glass-ceramic, which reportedly increases strength and temperature resistance (up to 500° C.). Corning scientists stress that the sealing properties of glass by heat treatment results in a virtually homogeneous boundary-free solid, without distorting channels or plugging nozzles.

Corning scientists also point out that internal circuit leakages, caused by improper sealing around a complex circuit's power nozzle, control ports, or other points, will cause changes in the resistance values of these circuits making them either good or bad to begin with.

This contrasts with the various load/life changes more common to electronic circuits that may take a period of time to show up.

Douglas Aircraft Co., Inc.
Santa Monica, Calif.

Douglas Aircraft Co. has directed an active program in fluidics for the past four years. All company-funded work is currently centered in the Missile and Space Systems Division's Advance Flight Mechanisms' stability and control branch. Initial studies were of components, but emphasis is now on systems.

A digital roll-control system using a special purpose digital computer for system compensation has been studied. A five-stage proportional amplifier was designed and tested to determine the effects of geometric parameters and design variables.

More recently, experiments were carried out to investigate design parameters in a supersonic pure-fluid bistable valve applicable to thrust vectoring. A second-order pneumatic autopilot was also designed and tested, using a digital control system based on a state-space control technique. This used OR, NOR, and AND gates supplied by Corning Glass.

Currently, a fluidic control study is underway to investigate the feasibility of pure fluid control systems for lightweight tactical missiles.

Emerson Electric Co.
St. Louis, Mo.

For over a year now, the Electronics and Space Div. of Emerson Electric Co. has been supporting a growing in-house program of research and development in the field of fluidic technology. The program grew out of extensive computer studies regarding the performance and control problems associated with future rockets and missiles. Particular emphasis was placed upon the solution of various control problems within the realizable dynamic performance characteristic of the pure fluid devices.

The company has made a substantial investment in the highly specialized equipment needed to pursue fundamental studies and development of pure fluid components and systems. Emerson Electric's primary interest centers around the development and application of sensors, linear amplifiers, mixers and high-power digital output stages. A second research facility, designed for developmental work on a new family of high-powered fluid control components, is presently under construction. Approximately 12 engineers, scientists and related personnel are working on fluidics.

Although the company is primarily interested in military and aerospace applications for fluidic control systems and components, a number of potential commercial developments are envisioned. For example, Emerson foresees the development of dependable, low-cost fluid control systems contributing to automation of manufacturing processes.

General Precision, Inc.
Little Falls, N.J.

Basic studies of fluid flow configurations, with an eye toward investigation of flow geometries that show promise for guidance and control elements, are being performed at GPI's research center, Little Falls, N.J. Scientists report emphasis has been placed on vortex flow devices, and test equipment for these studies has recently been placed in operation.

The firm reports no recent developments in its efforts on pneumatic computers, which were first reported several years ago.

Giannini Controls Corp.
Malvern, Pa.

A highly directed effort to develop high-gain proportional amplifiers, and an equally intense search for what Gian-

America's vital space centers...

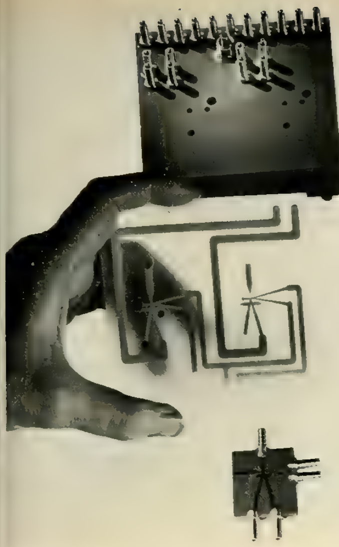
just a
DELTA
JET
apart!
DELTA/PAN AM THRU JETS TO AND FROM LONDON AND PARIS
SAN FRANCISCO
LAS VEGAS
LOS ANGELES
SAN DIEGO
KANSAS
FT WO
HOU
CHICAGO
DETROIT
NEW YORK
NEWARK
PHILADELPHIA
WASHINGTON
CINCINNATI
MEMPHIS
ATLANTA
NEW ORLEANS
TAMPA
ORLANDO
MIAMI
SAN JUAN
JAMAICA
CARACAS

- The only Jets between California and Atlanta-Orlando/Cape Kennedy
- 15 Jet flights daily between Dallas and California
- No lower Southern Airways – to – Jet fares between Huntsville and California than on Delta
- Deluxe and tourist on every flight

Call Delta or see your Travel Agent

DELTA®

the air line with the BIG JETS



FEASIBILITY of a single-package binary-to-decimal converter, measuring only 4 x 4 x ¾ in., is shown in comparison with standard NOR gate (bottom), circuit with two NOR gates (middle) and finished converter with 17 NOR gates (top). Designed by Corning Glass's fluid amplifier department, the device has 11 layers of fluidic circuits etched in photosensitive glass, converted into glass-ceramic for strength.

nini scientists call "the sensitive flows" (wherein a low-energy input flow can produce a high-energy change), have moved the firm's Astromechanics Research Div. into an important position within the fluidics industry.

The division's initial work, aimed almost exclusively toward amplifier development, has now been expanded into sensor and complete fluidic systems engineering.

Giannini has enjoyed particular success with its double-leg-elbow-amplifier (DLEA), considered one of the better-developed components in fluid technology. It reports that in a DLEA research program recently completed for the Army's Missile Command, the device demonstrated linear, repeatable differential mass flow gains of over 220:1—without serious effects due to large changes in supply flow or element size or moderate changes in output loading.

The DLEA actually employs some of the less understood internal flow phenomena—such as free-stream momentum redistribution through boundary layer control in a curving channel, and energy redirection by multiple flow mixing—and Giannini is still studying some of these basic flows under an Air Force contract to determine just why the DLEA does work so well.

Giannini has also just produced an enormous DLEA device which will act as a diverter valve in a NASA-Lewis lab test program (see page 35). The unit, delivered to NASA, is a non-vented pneumatic amplifier, reportedly the first of this type delivered by the firm. Giannini reports that the unit provides mass flow gains in excess of 100 and can handle more than 4 lbs. of air per sec. with less pressure loss than would be associated with a conventional control valve.

The firm is also under contract to the Air Force at Wright-Patterson AFB for development of what amounts to a pure-fluid air data computer. This device, reportedly, also found its roots in the earlier DLEA work and has grown into a concept for an analog ratio computer which in effect yields a free-stream Mach No. output proportional to the product of two variable input pressures—one from the aircraft's pitot tube and another from ambient static pressure measurement. The unit includes fluid conditioning networks, unit divider, subtractor, and multiplier.

It is now in Phase 1, and Giannini reports it has completed refining the component designs and hopes to deliver a breadboard system in June.

- **Where away?**—Giannini's in-house efforts are currently focusing on new sensors, particularly rate and temperature devices. The firm has produced in-house a new non-vortex-type rate sensor, which developers say has a frequency response superior to some vortex-type units. Scientists here estimate that fluidic rate gyros are now as good as medium-quality inertial units and can be improved. The firm is most interested in expanding fluidic systems into the final control elements, in many applications removing all mechanical interfaces.

Melvin Zisfein, general manager of the division, told M/R that many of the answers and future applications for these devices should come about through basic "rethinking" of what has become standard control system design procedure, including such things as sensor locations. He believes that availability of many fluidic components will now force this rethinking. "We are constantly reviewing concepts here," he reports. "We don't want to do things in this technology out of force of habit."

Heavily emphasizing proportional devices, scientists here also expect that analog, or hybrid digital-and-analog, systems will evolve in many applications faster than the straight digital computer systems envisioned early in the history of fluid technology.

Zisfein also considers that digital progress actually may have been hurt some by the immediate immersion in development of flip-flop-type circuits rather than perhaps some simpler form of gating. He further reports that there

LIQUID ROCKET INSTRUMENTATION ENGINEER

A responsible assignment is currently available in the Propulsion & Power Systems Department of our SPACE SYSTEMS DIVISION for an experienced graduate engineer who has acquired a significant background in liquid rocket motor test instrumentation and is capable of assuming supervisory and management responsibilities.

The position requires a thorough knowledge of the state-of-the-art, a familiarity with instrumentation and measurement techniques, experience with the planning and assembly of facilities for the conduct of liquid rocket motor tests and the knowledge necessary to select the test instruments required—flow benches, test cells, pressure transducers, etc. Also important is the ability to incorporate safety provisions in the field and laboratory testing of simulated and high-energy corrosive liquid fuels.

Occasional field trips of short duration will be required.

U. S. CITIZENSHIP REQUIRED

For immediate consideration, please airmail your resume to:

MR. ROBERT A. MARTIN
Head of Employment
HUGHES Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 19, California

HUGHES
HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS

An equal opportunity employer

is optimism in the area of device coupling, and says there should now be a major effort in size reduction.

Howie Corporation Philadelphia

The Fluid Logic Div. of the Howie Corp. (formerly H&H Machine Co.) through an agreement with R. N. Auger, developer of a particular type of fluid-state turbulence amplifier, has exclusive manufacturing rights to the device and conservatively estimates that it has sold units to more than 200 companies as an off-the-shelf stock item.

The Auger turbulence amplifier, which operates by modulating a laminar air stream with control pressures to create a turbulent flow which in turn alters the output pressure, is basically a simple device capable of performing logic and control functions. Because of its relative simplicity of fabrication and inter-connection, and relatively low cost, it has found applications faster than other types of fluid amplifiers, such as wall-attachment devices, for control.

Discussing the device with M/R, Howie engineers pointed out that the major limitations are in the area of switching speed and frequency response. The amplifier is limited to discrete signal frequencies of below 100 cps, they report, though it has a switching speed in the millisecond range.

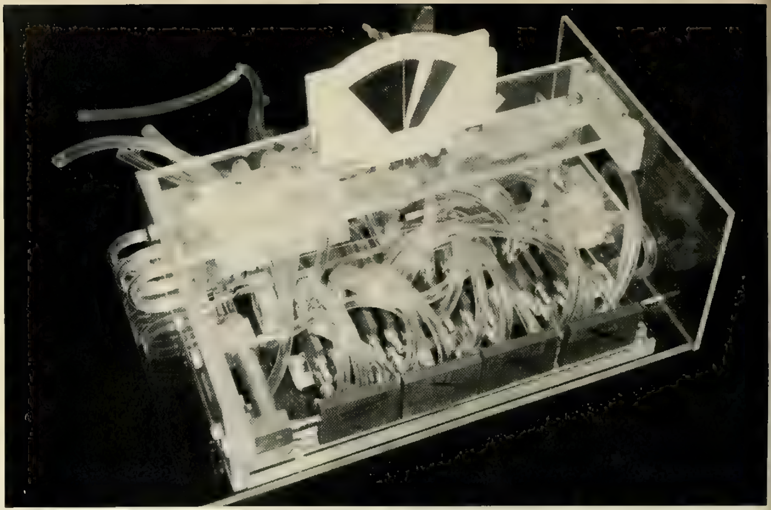
Turbulence amplifiers are currently made of nickel-plated brass. Future developments, say Howie engineers, will be to replace the thin-wall, "spaghetti-like" tubing for interconnecting amplifiers with etched channels and, eventually, to replace the amplifier itself with an etched configuration.

Hydraulic Research and Manufacturing Co. Burbank, Calif.

The main effort at Hydraulic Research and Manufacturing Co. centers on a "Hydrologic" comparator system for monitoring redundant control channels in high performance aircraft. Most of the components used have been proven in the company's line of electro-hydraulic equipment and include spools, sleeves, pistons, coil springs, cantilever springs, orifices and nozzles.

The most significant recent development is production of a hydraulic analog of the linear voltage differential transformer. This Hydrologic pressure monitor can detect position to within 0.001 in., is linear to 2% and is essentially unaffected by variations in supply pressure.

HRM activity in fluidics has been by way of evolution from conventional hydraulic systems, starting with development of the "Hydromat" unit. This algebraically sums mechanical and electrical inputs. Some 4,000 of these units have been used on flight controls in the F-106, A40-2N, A3J, and HU-1 aircraft.



THIS DIGITAL CONTROL system breadboard is being studied by Douglas Aircraft Co. for use as a second-order pneumatic autopilot.

Following this development came a requirement for redundant Hydromats and then for a monitoring capability. The Hydrologic comparator developed to meet this need could, for example, detect failure of a supersonic transport's redundant control surface and take corrective action in 10 milliseconds.

Advantage of the hydraulic scheme is absence of transducers and solenoid valves associated with more conventional electronic monitoring. The comparator operates off the aircraft's normal hydraulic supply. Key to the system is monitoring of control-valve spool position, rather than waiting for an actuator to integrate an error.

D. Wood, supervisor of the Hydrologic Systems Group, sees other applications for systems of this type in process control, nuclear power plants, and missiles. The company has developed a fluidic gyro with fluid pick-offs.

The advanced design group concerned with application of Hydrologic to present and future flight control systems, has a staff of six.

International Business Machines, Inc., Zurich, Switzerland

Having obtained what it feels to be most of the answers in the basic research aspects of fluid circuits, IBM-Zurich is now setting out to look at manufacturing techniques and applied principles. The IBM facility at Endicott, N.Y. is responsible for future product engineering. So far, however, the company feels no firm applications for IBM markets have yet been uncovered, although many appear promising.

Molded plastic plates containing entire fluidic circuits are inviting IBM initiative in Zurich, although engraved plates have been used for experimental circuits. The cost factor and potential accuracy of molded plastics seem a far better approach, developers feel.

IBM entered the fluidics field in 1956-57 to investigate circuits employing spool valves for logic applications. Beginning about 1960, research was shifted to emphasize pure fluid elements and, correspondingly, research into valve elements was reduced.

The company's interest in fluid circuits basically is for use in low-operating-speed machines with a limited flexibility and logic, to produce mechanical signals. Pneumatic connections can be used to link various machines. This approach has flexibility and speed advantages over mechanical equipment.

The Zurich lab is working on two types of elements, floating disc and pure fluid, with the former using moving parts. The valve system first researched has an insensitivity to input and output impedances, but is complicated and may suffer leakage during standstill periods. Pure fluid elements, on the other hand, are simple and logically powerful but require 100% power constantly. The floating disc elements consume no power during standstill periods and are generally between the pure fluid and valve elements in desirability.

H. H. Glaettli, director of the fluidics effort at Zurich, stressed that IBM does no real development work at the lab, confining its effort to basic research. However, testing of the status of experience is done by making small-scale application studies. The basic questions for which Glaettli and his associates now feel they have most of the answers include: How fast are such sytems? How small can they be made? What are the relationships between response time and amplification? What are the specific properties of such systems in use? What is the logic power?

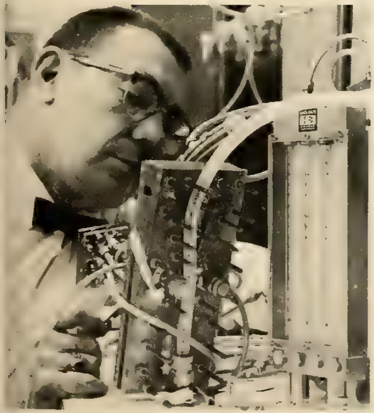
In valve systems, it was found that there was no advantage to going smaller than a diameter of one millimeter for response time benefits.

In the pure fluid elements, however, it appears that the minimum power required goes up as the element gets smaller. Conversely, the maximum power at which the element can be driven goes down as the element gets smaller. As one researcher pointed out, there comes a point in the reduction of size when these two power curves—the maximum and the minimum—meet each other. At this point, the element cannot be further reduced in size and still function as designed. Thus, for example, amplification may drop below a value of one or memories may be lost.

Having entered the phase of building a "bridge" between basic and applied research, IBM-Zurich is getting down to cases with equipment variations in experiments.

Having been using strictly vertical walls for the channels during initial experiments, the laboratory is now trying out certain other approaches. With all factors averaged out, it appears that an aspect ratio of 1 to 1.5 is a good compromise. Questioning the influence of oblique walls on the system and being unable to come up with a theory, the IBM team experimented and found that with reasonable values of angles, there is no significant effect.

However, an interesting result was obtained in searching out the consequences of internal surface roughness. With the channel walls rough, there is a drop in the Reynolds number; with the bottom and cover surfaces rough there is an increase in the Reynolds number; and with all internal surfaces rough, the effect balances out and the number remains essentially unchanged.


EMERSON ELECTRIC'S C. G. Philpott, director of research, examines components in a new experimental fluidic control system. The multistage unit was designed for missile flight-control applications.

Glaettli was somewhat critical of a current tendency to think only in terms of response time without also noting the other data involved, such as viscosity, density, Reynolds number and size. He also noted an inclination to think that a reduction in power meant a reduction in size, where a reduction in size increases the minimum power required.

IBM experience has shown that fluid amplifiers can be described completely by Reynolds number, Strouhal number, flow-rate gain and pressure gain. From these, response time can be deduced and power consumption calculated for any size element and any fluid.

A fundamental list of elements has been turned out by IBM-Zurich to simplify the task of assembling various circuits with a minimum of development unknowns. Comprised of about five basic elements, the list has been used to compile almost any kind of circuit (minus the memory). These include: complement generators, comparators, binary full adders, modified binary counters, binary two-grey code converters and vice versa.

Johnson Service Co.
Milwaukee, Wis.

Interest in pure-fluid components research at Johnson Service Co. began around the middle of 1960. A modest effort was made at that time to evaluate work done at the Harry Diamond Laboratories to determine its potential for use in environmental control systems. The results of this exploratory work were encouraging enough to continue the program and to gradually build up the effort.

The J.S.C. impact modulator was conceived and developed by October, 1962. This component in its various forms—direct impact modulators, transverse impact modulators, summing impact modulators, along with the three-terminal modulator—have been the backbone of Johnson's fluidic circuits and systems work.

Today, both researchers and product developers are engaged in components, circuits, instruments and systems work. Proportional acting components and circuits have been given the major attention.

This effort is divided into two channels of work—one for commercial applications and another to meet government needs. Presently, Johnson has a $50,000 contract with Harry Diamond Laboratories for developing a special high gain amplifier and an analog computer capable of solving a second order

ROCKETDYNE

Career Openings in Solid Propulsion

Rocketdyne's Solid Rocket Division in Central Texas offers outstanding opportunities to advance professionally in solid propulsion research, engineering, and production. Current major programs include Phoenix, Sparrow, Shrike, and Sidewinder.

Applied Mechanics

Conduct analyses in structural mechanics, mechanical shock and vibration, and viscoelastic stress, as related to solid rocket motors. Strong background in mathematics and one or more of above listed applied mechanics fields is necessary.

Ignition Systems

Conduct design, analysis, and development of solid rocket motor ignition systems.

Internal Ballistics

Conduct design and specification of solid rocket motor ballistic characteristics and charge design, plus analysis and evaluation of performance, using principles of thermodynamics, fluid mechanics, and stress analysis.

Value Control

Conduct value engineering analyses utilizing techniques predicated on past training and design experience, and direct organized teams in systematic cost reduction efforts as related to engineering product designs and associated criteria.

Reliability

Conduct reliability analyses and studies relative to solid propellant motor designs, and serve as senior reliability representative to specific program task teams and related special project activity.

Chemical Processing

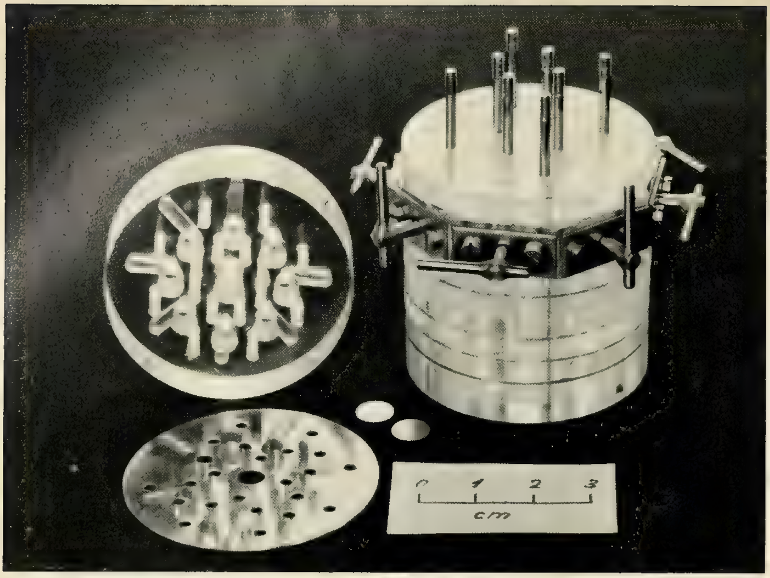
Conduct design, analysis, and development of manufacturing processes associated with solid propellant propulsion systems.

Address inquiry or resume in confidence to:

Mr. D. B. Whayne
Professional Employment
Rocketdyne, Box 548
McGregor, Texas

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

North American Aviation
Rocketdyne Division



DIGITAL FILTER using floating disc elements was developed by IBM-Zurich.

differential equation with constant coefficients. This is the second contract with HDL. The first one was completed in May, 1963. Both contracts have been at the same level of effort.

Presently JSC is planning programs of research in flight control systems but is not engaged yet in this work.

By far, the company's largest effort is in research and product development directed toward products applicable to environmental control systems. The goal has been to improve the currently existing highly reliable pneumatic systems by eliminating as many of the pivots, levers, diaphragms and other moving parts as possible from these systems.

One of the basic circuits that has been developed, and around which many instruments and applications can be built, is the operational amplifier. By appropriate feedback arrangements the operational amplifier may be employed as a summer, or a differentiator, or an integrator, which are the basic building blocks of many electronic-like instruments.

The first commercial instrument to be disclosed by any manufacturer, according to J.S.C., is the firm's impact modulator controlling-receiver. The controlling-receiver has for several years been a basic building block in pneumatic transmission systems. The heart of the impact modulator controlling-receiver is the operational amplifier. J.S.C. believes the system offers more flexibility and greater stability than the older mechanical type.

Plastic materials are being used where temperature applications do not exceed 200°F. For higher temperatures, stainless steel is used and ceramics are being considered.

Johnson sees a growing interest in pure fluid circuits and has indicated plans to continue its effort in circuits work for proportional systems and in the area of digital circuits.

Martin Company
Orlando, Fla.

The Martin Company's Orlando Division is a relatively late starter in fluidics but has gained ground rapidly, particularly in the area of fluidic subsystem miniaturization. A proprietary fabrication technique and clever designing enable engineers using etched thin plates to produce circuit geometries and stack them to produce a complete working component.

The firm has just completed a 150-x-250-ft. fluidics R&D laboratory, including fabrication and test areas. Equipment includes built-in high- and low-pressure source panels, flow meters, 10-kc anemometer, a Schlieren system to study flows and densities, and photographic and etching equipment.

The division began its organized in-house R&D program in fluidics in January, 1964, although it had worked with some pneumatic techniques earlier. A pneumatic accelerometer was developed in 1963.

As of December, 1964, the group held no outside contracts, but it expects both Army and Air Force support early this year. It now employs seven full-time scientists and engineers in its fluidics development lab.

Company-funded efforts here are aimed primarily at development of complete fluidic control systems for small tactical missiles and for a large missile backup control system designed to survive intense nuclear radiation environments.

In its stacked planar arrays, Martin is employing brass or beryllium-copper material. Developers claim the logic planes can be produced with great precision and at very low cost—a fraction of the cost of comparable electronic circuits.

In the area of miniature computer circuits, Martin feels that interconnection problems preclude the use of tubing between modules or elements operating at high clock rates. All high-pressure sections of a fluidic digital computer must be designed in a single module where short connecting lines from element to element or plane to plane can be implemented. Manifolding techniques to slower operating peripheral equipment can be used, however.

- **Stacking**—One technique that has solved many interconnecting problems is arranging the logic elements in planar arrays stacked to provide a completed system with the necessary passages and transfer paths between planes. This method was used for fabrication of a miniature binary counter at Martin-Orlando. Any desired counter capacity can be obtained by stacking the required number of logic planes. In this layout all signal path lengths are less than ½-in. long in the planar array, and no signal must communicate vertically in excess of one plane thickness. This enhances both operating frequency and signal recovery.

Charles Borcher, head of Martin-Orlando's fluidics research effort, said that techniques being used here allow asemblies with component densities of several hundred per cubic inch. "Techniques are being explored," he disclosed, "that promise densities of 1,000 per cubic inch in the near future."

The only substantial cost involved is in laying out the initial circuit and refining it to the point where satisfactory operation can be assured. Design changes and improvements are very easy to incorporate by changing the art of the faulty component and cutting a new circuit. Portions providing satisfactory performance need not be disturbed. Once the circuit has been established, hundreds of the systems can be produced for a very nominal cost, said Borcher.

Moore Products, Inc.
Spring House, Pa.

Moore Products, Inc., a manufacturer of very large no-moving-parts fluid-diverter valves, claims it has delivered more fluidic systems for actual industrial applications than anyone else in the business.

The firm, an early licensee of Bowles Engineering, has delivered devices—some reportedly large enough to walk through—to steel, chemical, paper and pulp industry firms.

Although the fluidic systems portion of the firm's total business is still not yet profitable, a company spokesman pointed out that the situation is not uncommon to the entire fluidic systems industry at this point.

North American Aviation, Inc.
Downey, Calif.

Main emphasis of work at North American Aviation's Autonetics Div., is on control-systems applications for aircraft and missiles.

Limited studies are being made of computer applications. Advanced studies are investigating some "unique techniques of a classified nature," according to a division spokesman.

Designs have been made for applications to advanced systems, the most significant being in flight controls. The specific applications are classified, but switching characteristics for a particular missile control system are characterized as follows: transducer response, 100-500 microsec.; particle transition 150-1,000 microsec.; switching 50-500 microsec.

One of Autonetics projects closely parallels that program now being conducted under Army sponsorship at Redstone Arsenal with its fluidicly controlled *TIM* missile. The Autonetics control system, from sensor to output torque, will be fabricated using pure-fluid devices exclusively.

The virtues of the fluidic control system that recommend its use to control movement about the roll axis of a missile also apply to the other two control axes. But these call for roughly 10 times the output that the roll axis requires.

The Autonetics development program is geared to demonstrate that higher power levels can be controlled by pure fluid devices without losing system stability through self-excited oscillations or excessive phase shift from increased component time lags. With little emphasis on optimizing component size or packaging, no flight testing of the prototype system is anticipated. A probable second phase of the program would aim at reducing the system envelope, for simulated flight testing.

Component and system tests will use equipment now in three facilities—a barometric lab, a high temperature facility and a hydraulics lab. Additions in the final planning stage include a pneumatic test stand capable of supplying regulated pressures from 0.01 to 500 psig at flows from 0 to 500 SCFM. Associated instrumentation will include hot-wire anemometers and laminar flow transducers.

The technical staff working on the program is made up of a senior research specialist with 15 years experience in conventional fluid power development, a staff consultant with five years of background with fluidic devices, and research engineering and laboratory personnel associated with the three facilities. A mixture of analytical research personnel and engineering development personnel are under direction of flight controls management. System applications personnel are applying the technologies and devices to complete systems.

Some of the chief technological problems recognized are those that center about the basic empirical nature of the devices and the lack of suitable analytical techniques for design and evaluation. Dynamic transfer functions and methods of predicting and simulating them are definitely needed. Likewise, much more extensive parametric quantitative data are required to enhance widespread application to the kinds of products that Autonetics markets.

Parker
METAL V-SEAL
A RELIABLE WEIGHT REDUCING SEAL FOR EXTREME ENVIRONMENTS

Today's engineer must cope with such environments as temperatures ranging from −423°F. to plus 2000°F., from hard vacuum to high pressures, and exposure to extremely volatile and corrosive media or radiation. Parker's Metal V-Seal represents a significant achievement in the search for an effective, economical and weight reducing static face seal to meet these extreme demands . . . Designed, engineered and made to Parker's high standards of quality and dependability.

BASIC ADVANTAGES:
- High resistance to corrosive and volatile chemicals
- Low flange loads to minimize system weights
- High resiliency to compensate for flange deflections
- No special flange machining required (can be made to fit almost any existing groove and some styles do not even need a groove!)
- Reusable several times under most conditions
- Wide variety of seal metals, platings, and coatings to meet specific requirements
- Full range of standard sizes from ¼" to 15" O.D. (Larger on special order)

Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio

Want more information?
Send for Catalog 8800

Circle No. 8 on Subscriber Service Card

Systron-Donner Corp.
Concord, Calif.

A fluid-rotor angular accelerometer that maintains accuracy during linear accelerations and high vibration has been developed under contract by Systron-Donner Corp. The instrument makes use of the company's Model 4590 Angular Servo Accelerometer and silicone fluid as a seismic sensing medium. The fluid is contained in a toroid blocked by a servoed torque generator.

Applications foreseen for the unit include artificial mass augmentation for raising inertial platform stability. Also it could be used as a simple, low-cost means for stabilizing helicopters and aircraft.

Typical ranges for the unit are ±1 radian/sec^2 and ±2 radian/sec.^{2}

United Aircraft Corp.
East Hartford, Conn.

UAC's Research Laboratories have been engaged since 1959 in a continuing program of research sponsored by Harry Diamond Labs to investigate the basic characteristics of jet flows in fluidic components.

The program, according to UAC scientists, has included studies of compressible turbulent submerged jet flows and the pressure recovery characteristics of diffusion systems capturing these flows. The types of flows under study include those associated with free jets, wall-type jets, impinging jets, and reattaching jets.

UAC reports results of these studies are providing data required in the development of analytical design procedures for predicting both the steady-state performance and the dynamic response of fluid devices.

UAC has maintained a company-funded research effort for about five years, and a portion of this has been directed into analytical design-procedure development.

For example, UAC scientists told M/R that procedures for predicting the steady-state performance of momentum-exchange proportional amplifiers over a wide range of input and output impedances and power jet Mach numbers has been developed and programmed for machine computation. Amplifier performance predicted by this procedure, they report, is generally within 10% of the measured values. UAC is now at work attempting to further refine the procedure.

A similar program is under way for bi-stable wall attachment devices, and an analytical study of factors affecting time response for these has been completed.

UAC has also sponsored company work on a thrust vector control (TVC) system. This scheme consists of a fluid amplifier and crossover unit combination to direct secondary gases from chamber bleed or an auxiliary gas generator into the propulsion nozzle for thrust vector control, or alternately in the axial direction when thrust vectoring is not required. Modulation from one mode to the other is accomplished with control jets located at the exit of the amplifier power jet.

By use of the crossover unit, UAC reports, the pressure in the non-flowing passage of the amplifier is approximately equal to the static pressure at the exit of the flowing passage, thereby rendering the unit insensitive to ambient pressure of the nozzle exit pressure. In an actual application, four vectoring units—one in each gradient—would generally be employed.

Fluid systems applications work at UAC's Hamilton Standard Div. is being fed by developments at the research lab, and Hamilton Standard engineers say the division is pursuing three basic areas: fuel controls for jet engines, including speed-, pressure-, and temperature-sensing devices; air inlet controls and stability augumentation systems for supersonic aircraft; and environmental conditioning systems for aircraft. Both digital and proportional devices are being explored.

Hamilton Standard is optimistic about fluidic systems acceptance and is expanding its 30-man team at work in this area. The group is placing major emphasis on early use of some of its capabilities with electron beam welding for fluid state circuit fabrication, using various metallics (primarily stainless steel), and for stacking and sealing purposes.

Non-Profit Organizations

Case Institute of Technology
Cleveland

A continuing program of pure fluid research, some of it government supported, is being carried out at Case's engineering design center. Attention is focused on establishing the role of the pure fluid devices in the automatic control field, and on the design and development of a fluidic digital feedback system.

Discussing program progress, Associate Professor Charles K. Taft, who heads the Case effort, reports that a new prototype counter and quantizer have been developed and are in operation, as are a prototype actuator and power amplifier. An alternate vortex-type power amplifier has also been designed, which reportedly provides reduced standby-power losses. The university also reports development and operation of a pure fluid digital/analog converter and a new flow measuring technique for obtaining an electrical signal proportional to air flow rate.

Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y.

CAL is now working under a $174,000 Air Force Systems Command (Aero Propulsion Lab at Wright-Patterson) project for experimental fabrication and demonstration of a pneumatic-flow instability sensor for use in advanced turbine engines.

Details of the effort are classified, but it is known that the contract is scheduled for completion this September.

A minimal in-house research program at CAL is designed to help technical personnel monitor and stay abreast of fluidics state of the art.

The Franklin Institute
Philadelphia

The Institute's Research Laboratories, primarily the control systems laboratory, is concentrating on two areas within fluidic systems technology: the development of servomechanism analysis techniques, and the development of test equipment—virtually non-existent—for the fluid technology. The Institute has been supported in some areas by Harry Diamond Lab contracts.

Massachusetts Institute of Technology, Cambridge, Mass.

MIT is under contract to both the Air Force and NASA in the fluidic technology effort, primarily in projects aimed at establishing some of the basic fluid-state operating principles. The effort, started in 1959 and now carried on primarily through the offices of assistant professor Forbes T. Brown, is concerned at this point with basic stability and response parameters of both fluidic elements and systems, and the means for practical ways to measure and predict device and ultimately "black-box" behavior.

Under its NASA contract, MIT is studying two basic approaches for measuring component characteristics: the so-called "admittance approach" for low-frequency devices, and the acoustic testing of components for HF elements.

The university, with continued development of test procedures, hopes to accumulate a considerable amount of test data for a few widely used amplifiers, and to demonstrate the application and usefulness of the results.

Sandia Corp. Albuquerque, N.M.

Investigation of possible uses of fluidics is underway at Sandia Corporation. The Atomic Energy Commission prime contractor operates two laboratories that design and monitor production of ordnance components and systems destined for use in nuclear weapons.

One out-of-house effort presently under way is development of a 60-second timer with multiple fixed and settable time outputs. This contract was started at Sperry Rand's Univac Div. facility at Blue Bell, Pa., in May, 1963, and will be completed in early 1965. Contracts probably will be placed shortly thereafter for a variety of fluidic devices.

Outside expenditure rate is now $7,000 per month on the $100,000 contract. An approximately ten-fold increase is expected in 1965.

Through 1963 and early 1964, the in-house fluidics effort involved use of less than two full-time employees. Later, however, the workload was expanded to require about 4.5 men and will probably remain at this level. Research is presently centered in Sandia's Advanced Development Div. under R. P. Stromberg.

The division is expanding its laboratory facilities to perform evaluations of supplier-furnished designs and to permit limited original in-house experimentation. The engineering/technical staff engaged in fluidics is composed mostly of mechanical engineers with one electrical engineer, all at the M.S. level.

The Advanced Development Div. sees the chief technological problems in fluidics as: developing stable elements capable of being easily interconnected; developing non-critical element geometries that are easily fabricated; developing the associated hardware for fluidic devices such as power supplies, pressure switches and interconnection schemes. Finally, and perhaps most importantly, Sandia believes fluidic devices must be tested extensively over a wide range of environments to determine conclusively if they are as rugged and reliable as purported.

Stanford Research Institute Stanford, Calif.

Stanford Research Institute started work in fluidics in 1960 and has held its effort at a relatively low level ever since. About five members of the staff of the Control Systems Laboratory under group head Robert Muffley are actively involved in fluidic research. Averaged over a year the effort amounts to 1½-2 full-time staff, with assistance from the SRI computer group.

The laboratory has developed a new class of fluid amplifiers in which a balance of forces on two balls of different size control air-pressure signals. Two balls form a logical inhibitor, three comprise a two-input NOR. Either element can combine in networks for all binary logic functions.

Units have been made as small as 0.04 cu. in. per NOR with interconnections. Power consumption of 10 milliwatts and switching times of 1.7 milliseconds have been measured. Supply pressures have ranged from 0.1 to 100 psig. Ball diameters between 1/16 and 3/8 in. frequently are used.

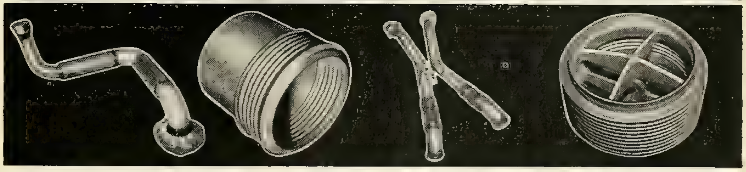
The two-ball element also can be combined with flow restrictors to act as an operational amplifier for analog summing and integration.

An in-house study by the Computer Group cast grave doubt on the feasibility of fluidics devices for use in a simple desk-top computer. High power consumption, slow speed, large numbers of components, and difficulties with the power supply were major drawbacks.

Studies of specific applications of fluidic devices showed their use in gas bearing control led to important improvements in stiffness, stability, and power consumption. Work on this aspect was carried out under a $20,000 contract from NASA. ■

designed
UN•USUAL

Heat exchanger exhaust duct bellows. Manufactured from Hastelloy "C" to withstand high temperatures. 30" I.D.



Stainless steel cryogenic lines. Flexible; to resist both high bending and twisting forces.

Inco 718 bellows assembly with Inco 718 extensions. This 9" diameter assembly is proof tested at 3000 psig.

Jet engine fuel supply line. Thin wall tubing combined with braided flex-sections. Stainless for corrosion resistance and light weight.

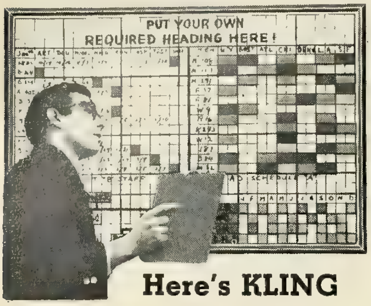
Stainless steel bellows assembly with A286 stainless link joint. The restrictor links permit controlled angulation of the planes of the ends in this 9½" bellows assembly.

When unusual problems in ducting and bellows require unusual answers, consider the experience of DK Manufacturing Company in helping solve unusual problems. You will find many good reasons, evidenced by some of the unusual products shown above, to give us an opportunity to work for you. You will find the unusual becomes the usual faster at DK. Write or call for information.

AEROSPACE DIVISION
D K MANUFACTURING COMPANY
100 North Island Ave., Batavia, Illinois

Circle No. 9 on Subscriber Service Card

Don't Remember
Use a KLING Visual Control Board



Here's KLING Visual Control Board with MAGNETS!

ONE SYSTEM TO CHART YOUR PROGRESS
Lightweight, white steel board with aluminum frame, 24" x 36", blank with 1" square gridlines, 50 color-coded magnets, and markers. Write on magnets and/or boards—or erase—for complete flexibility! No pins. No pegs. No flimsy cards.

$35 complete, ready to use, with magnets, markers, & aluminum frame!

ON APPROVAL TO RATED FIRMS—or send for free booklet #M6

Regal & Wade Mfg., Inc. / KLING SYSTEMS
Maspeth, New York 11378

Circle No. 10 on Subscriber Service Card

FREE
ZERO DEFECTS KIT

Includes:

- Procedure for organizing, planning and implementing a Zero Defects Program
- The Fundamentals of Zero Defects including the 4 "I's" of Error-Free Performance
- Personal Pledge and Achievement Card
- Zero Defects Motivation Posters actual multi-color samples 17"x22"

This valuable kit is yours without obligation. Simply fill out the coupon and mail it today.

ELLIOTT SERVICE COMPANY, INC.
Mount Vernon, New York

ELLIOTT SERVICE COMPANY, INC.
Dept. B, 30 N. MacQuesten Parkway
Mount Vernon, N.Y.
Please provide me with the Elliott "Zero Defects Kit."

Name____________________
Title____________________
Firm____________________
Address__________________
City_______ State______ Zip Code______

contracts

AIR FORCE

$2,100,000—**Radio Corp. of America,** Missile & Surface Radar Div., Moorestown, N.J., for the ECCM program.

$1,640,000—**General Electric Co.,** Utica, N.Y., for production of electronic equipment.

$1,598,500—**Douglas Aircraft Co., Inc.,** Santa Monica, Calif., for *Thor* space boosters.

$1,400,000—**Bunker-Ramo Corp.,** Canoga Park, Calif., for continued research and development work on control systems for unspecified weapons.

$1,100,000—**General Electric Co.,** Philadelphia, for continued development and testing of space payloads.

$1,075,602—**Drexel Dynamics Corp.,** Horsham, Pa., initial funding on a $2-million contract for quantities of airborne weapons training devices.

$290,000—**Varian Associates,** Palo Alto, Calif., for microwave tubes.

$149,980—**Ohio State University Research Foundation,** Columbus, Ohio, for investigation, transmission of intense laser radiation.

$131,029—**McDonnell Aircraft Corp.,** St. Louis, for R&D on the *ASSET* program.

$64,000—**TRW Space Technology Laboratories,** Redondo Beach, Calif., for research on charge particle diagnostics.

$37,500—**Douglas Aircraft Co., Inc.,** Missile and Space Div., Santa Monica, Calif., for corrosion studies of forged beryllium.

ARMY

$2,685,483—**Philco Corp.,** Newport Beach, Calif., for *Pershing* study program.

$700,000—**Walter Kidde & Co., Inc.,** Belleville, N.J., for production of compressor equipment for the *Pershing* missile.

$600,000—**Philco Corp.,** Newport Beach, Calif., for design changes with respect to *Shillelagh* missile capabilities.

$541,762—**Dynalectron Corp.,** Washington, D.C., for logistical support services at Green River Test Complex, Utah.

$535,000—**International Telephone and Telegraph Corp.,** Federal Electric Corp., Paramus, N.J., for operation and maintenance of a tropospheric scatter radio communications system in Japan.

$371,000—**Carpenter Bros.,** Dallas, for furnishing and installing equipment for test maintenance building at Mississippi Test Facility.

$364,995—**Hughes Aircraft Co.,** Culver City, Calif., for feasibility study, *TOW* airborne.

$256,537—**Smith and Sapp Construction Co.,** Orlando, Fla., for MSC *Apollo* service module propulsion test facility at Cape Kennedy Air Force Station.

NAVY

$26,601,966—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for R&D work on a re-entry system for *Polaris* missiles.

$8,000,000—**Texas Instruments, Inc.,** Dallas, for production work on *Shrike* missile guidance, control and airframe equipment.

$6,209,327—**General Dynamics Corp.,** Groton, Conn., for overhaul work on two *Polaris* submarines.

$1,104,414—**Raytheon Co.,** Bedford, Mass., for flight tests for the improvement of the *Sparrow* system.

$150,000—**C-E-I-R, Inc.,** Arlington, Va., one-year extension for basic statistical services relating to the *Polaris* weapon system.

$49,986—**M-Tech Corp.,** Pomona, Calif., for R&D work on *Tartar* weapon system.

$25,000—**Perkin-Elmer Corp.,** Norwalk, Conn., for a spectroradiometer for solar simulator studies.

NASA

$2,400,000—**General Telephone & Electronics Corp.,** Waltham, Mass., for design and construction of a transportable ground station for use in advanced satellite communications tests.

$2,172,517—**Telecomputing Services, Inc.,** Panorama City, Calif., for continued operation of computers and data transmission equipment at Michoud Operations, New Orleans, La.

$1,327,040—**Sperry Rand Corp.,** Univac Div., Washington, D.C., for two communications processor systems.

$1,224,063—**Beckman Instruments, Inc.,** Fullerton, Calif., for satellite telemetry automatic reduction systems.

$700,000—**Philco Corp.,** Western Development Laboratories, Palo Alto, Calif., for design and development of a radiation detection system for the *Apollo* manned lunar spacecraft.

$210,630—**University of Iowa,** Iowa City, Iowa, for instrumentation for potential dc scintillator experiments.

$175,000—**Douglas Aircraft Co., Inc.,** Missile & Space Systems Div., Santa Monica, Calif., for investigation of the influence of a variety of mission requirements on design of space logistics vehicles.

$65,000—**Illinois Institute of Technology,** Chicago, for research on a gaseous-core nuclear rocket.

$23,496—**Rocket Research Corp.,** Seattle, for a feasibility study of a long-life valveless pulse rocket for control of satellites and space vehicles.

INDUSTRY

$3,400,000—**Giannini Controls Corp.,** Duarte, Calif., from **Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for design, development and production of a nucleonic propellant quantity gaging system.

$2,500,000—**Linbeck Construction Corp.,** Houston, from **Rice University,** Houston, for construction of a space science and technology building.

$1,000,000—**Honeywell, Inc.,** Minneapolis, Minn., from **North American Aviation, Inc.,** Autonetics Div., Anaheim, Calif., for production of accelerometers for *Minuteman II*.

$532,000—**Electronic Memories, Inc.,** Hawthorne, Calif., from the **Boeing Co.,** Seattle, for memory devices for the flight programmer on *Lunar Orbiter*.

$208,000—**Sterer Engineering and Manufacturing Co.,** Los Angeles, from the **Boeing Co.,** Seattle, for provision of regulators and cold-gas thrust devices for attitude control of the unmanned *Lunar Orbiter* spacecraft.

Consolidated Controls Corp., El Segundo, Calif., from **General Dynamics/Astronautics,** San Diego, Calif., for production of destruct mechanisms to be used with *Surveyor* spacecraft.

ARMS CONTROL AND DISARMAMENT AGENCY

$84,314—**Midwest Research Institute,** Kansas City, Mo., for a study of the shipbuilding industry.

$80,000—**The State of New York,** Department of Labor, Division of Employment, for a study of the impact on the Long Island labor force of defense contract phase-outs ($40,000 of contract funded by DOD).

$53,739—**Denver Research Institute,** Denver, Colo., to prepare a series of industrial conversion case studies.

ATOMIC ENERGY COMMISSION

$800,000—**Aerojet-General Corp.,** Nucleonics Div., San Ramon, Calif., for a one-year R&D program in fissiochemistry.

DEFENSE SUPPLY AGENCY

$95,000—**Fairchild Camera & Instrument Corp.,** Du Mont Laboratories, Clifton, N.J., for production of cathode ray tubes.

let us move with you!

Six Weeks Is Required To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, **if possible, the address label from your last issue . . .** include your postal zone or zip number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

◆◆◆

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Geneva, Switzerland—10 Rue Grenus; Geneva 321044

Paris, France—11 Rue Condorcet; TRU 15-39

—when and where—

FEBRUARY

Unmanned Exploration of the Solar System, sponsored by the American Astronautical Society, the American Astronomical Society, American Geophysical Union, American Institute of Biological Sciences, IEEE and AIAA, Denver Hilton Hotel, Denver, Feb. 8-10.

Spring Meeting of the American Society for Testing and Materials, Statler-Hilton Hotel, Cleveland, Ohio, Feb. 8-12.

50th Norelco X-ray Analytical School, Willard Hotel, Washington, D.C., Feb. 8-12.

Flight Testing Conference, sponsored by the AIAA and NASA, Huntsville, Ala., Feb. 15-17.

Third Annual Conference of the Electronic Sales-Marketing Association, Summit Hotel, New York City, Feb. 15-17.

1965 Electrical and Electronic Trade Show, sponsored by the Electrical Representatives Club and the Electronic Representatives Assn., Denver Auditorium Arena, Denver, Feb. 15-17.

Fourth Annual Photo-optical Workshop and Product Display, sponsored by the Society of Photo-optical Instrumentation Engineers, Statler Hilton Hotel, New York City, Feb. 17.

International Solid State Circuits Conference, sponsored by the University of Pennsylvania and IEEE, Sheraton Hotel, Philadelphia, Feb. 17-19.

Annual Meeting of the United States Naval Institute, U.S. Naval Academy, Annapolis, Md., Feb. 18.

National Air Meeting of the Institute of Navigation, in conjunction with the Army, Navy and Air Force (classified confidential), State Department Auditorium, Washington, D.C., Feb. 18-19.

Sixth Annual West Coast Reliability Symposium, sponsored by the American Society for Quality Control and UCLA Engineering Dept., UCLA Campus—Moore Hall, Los Angeles, Feb. 20.

1965 Western Metal and Tool Exposition and Conference, sponsored by the American Society for Metals and the American Society of Tool and Manufacturing Engineers, Great Western Exhibit Center and Biltmore Hotel, Los Angeles, Feb. 22-26.

Annual Meeting of the Aerospace System Safety Society, International Hotel, Los Angeles, Feb. 24-26.

Fifth National Symposium of the Society for Information Display, Miramar Hotel, Santa Monica, Calif., Feb. 25-26.

MARCH

Symposium on High Speed Testing, sponsored by Massachusetts Institute of Technology and Brooklyn Polytechnic Institute, Sheraton Plaza Hotel, Boston, March 8-9.

Advertisers' Index

AEROJET-GENERAL CORP., SUB.-THE GENERAL TIRE & RUBBER CO. 56
Agency—D'Arcy Adv. Co.

BOEING CO., THE 2
Agency—Campbell-Ewald Co.

BROWN ENGINEERING CO., INC. 9
Agency—Smith-Kirkpatrick Adv., Inc.

DK MFG. CO., AEROSPACE DIV. 51
Agency—Stevens, Kirkland, Stabelfeldt, Inc.

DELTA AIR LINES, INC. 44
Agency—Burke Dowling Adams, Inc.

DOUGLAS AIRCRAFT CO., INC.
AIRCRAFT DIV. 43
MISSILE & SPACE SYSTEMS DIV. 5
Agency—J. Walter Thompson Co.

ELLIOTT SERVICE CO., INC. 52

GENERAL PRECISION, INC., KEARFOTT DIV., AEROSPACE GROUP 16, 17
Agency—Gaynor & Ducas, Inc.

GRUMMAN AIRCRAFT ENGINEERING CORP. 41
Agency—Newmark, Posner & Mitchell, Inc.

HUGHES AIRCRAFT CO. 8, 45
Agency—Foote, Cone & Belding

HYDRAULIC RESEARCH & MFG. CO. 28, 29
Agency—Mann Adv. Co., Inc.

ITT FEDERAL ELECTRIC CORP., DIV. INTERNATIONAL TELEPHONE & TELEGRAPH CORP. 27
Agency—Deutsch & Shea, Inc.

LEDEX, INC. 4
Agency—Yeck & Yeck

MINNESOTA MINING & MANUFACTURING CO., MINCOM DIV. 23
Agency—Reach, McClinton & Co., Inc

NORTHROP CORP. 24, 25
Agency—Doyle, Dane, Bernbach, Inc.

PAN AMERICAN WORLD AIRWAYS, INC., GUIDED MISSILES RANGE DIV. 33
Agency—Deutsch & Shea, Inc.

PARKER SEAL CO. 49
Agency—The Lester Co.

REGAL & WADE MFG., INC./KLING SYSTEMS 52
Agency—Lee/Bader & Rose, Inc.

ROCKETDYNE, DIV. OF NORTH AMERICAN AVIATION, INC. 47
Agency—Batten, Barton, Durstine & Osborn, Inc.

SPACE TECHNOLOGY LABS., SUB. OF THOMPSON RAMO WOOLDRIDGE, INC. 6
Agency—Fuller & Smith & Ross, Inc.

VARIAN ASSOCIATES 55
Agency—Hoefer, Dieterich & Brown, Inc.

CLASSIFIED

FOR SALE OR LEASE

5000 GALLON—53# W. P. DEWAR SUITABLE FOR OXYGEN, NITROGEN, OR HYDROGEN. AVAILABLE IMMEDIATELY.

NATIONAL ANNEALING BOX COMPANY
Washington, Pennsylvania

Onward and Upward

RETURN OF A NOTE OF OPTIMISM to the industry, following the defense and space budget announcements, is a welcome development. There never has been a real question as to the industry's health and future. But we are pleased that a number of prominent spokesmen, in the industry and in the government, have seen fit to emphasize this fact.

Briefings by Defense Dept. spokesmen, who have stressed the "plateau" nature of current defense spending, have been beneficial. The importance of these statements lies in the fact that the so-called plateau is seen as a floor from which defense spending inevitably must rise to some degree—not as a ceiling from which it will decline.

The overall defense budget of $49 billion, of which nearly $24 billion is available to the industry, is a healthy one. President Johnson, Secretary of Defense McNamara and associates, after a careful review of military needs and strategy, have concluded that the nation's defense budget cannot be pared below this without endangering the security of the country. We agree.

We also agree with their philosophy that, barring unwelcome international difficulties, the defense budget can and should occupy a smaller share of the gross national product in percentage terms. But a decline in percentage share is in no way a decline in absolute terms, a point the Administration now has made clearly enough to put an end to the doom-shouting.

Taken together, the defense and space budgets represent a growth market. The President is as committed to a financially sound space program as he is to a financially sound defense program.

Spending for both these areas will go up. It will not go down. We anticipate some severe disagreements with the manner in which the money is spent. We certainly have no quarrel with the Administration's overall philosophy toward defense and space spending.

This viewpoint is reflected in industry statements of recent days. Lockheed Board Chairman Courtlandt Gross told a businessmen's meeting in Philadelphia that "the industry in general is in the soundest financial position ever, and prospects are for continued improvement."

Commenting on the Arthur D. Little report, which we took to task on this page recently (M/R, Jan. 25, p. 46), Mr. Gross pointed out that the report "does not show the effect of the updating and modernization of obsolete weapons systems which we think will take place."

He also noted that the report failed to recognize other growth areas for the industry, adding:

"The aerospace industry, employing almost a third of all privately employed engineers and scientists—and disbursing more than a third of all funds for research and development in the U.S. economy—is by a wide margin the industry of science and technology."

"As such," he commented, "I cannot see how it can fail to be a very important industry of the future."

The Lockheed executive cited not only the growth potential in space vehicles and aircraft, but also the prospects in such peripheral industry areas as ocean systems, nuclear applications, electronics and communications, cargo handling and shipbuilding. We believe our views on the industry future in such areas of advanced technology are familiar to our readers.

An excellent example of this is found in the special report on fluidics in this issue. Here is a whole new area of advanced technology which has developed in the last few years from the competence of this industry. Its potential is seen in market estimates running as high as $250 million annually for a growth period in the years directly ahead. The precise future of fluidics remains to be determined, but there is no question that the industry has developed an important new area of interest.

ANOTHER INDUSTRY SPOKESMAN who has stepped forward in recent days in defense of the future is Dolor P. Murray, fiscal vice president of McDonnell Aircraft Corp. Mr. Murray told the New York Society of Security Analysts that McDonnell forecasts a sales and earnings increase of at least 10% in Fiscal 1965. He predicted that sales in Fiscal 1966 and 1967 will be even healthier.

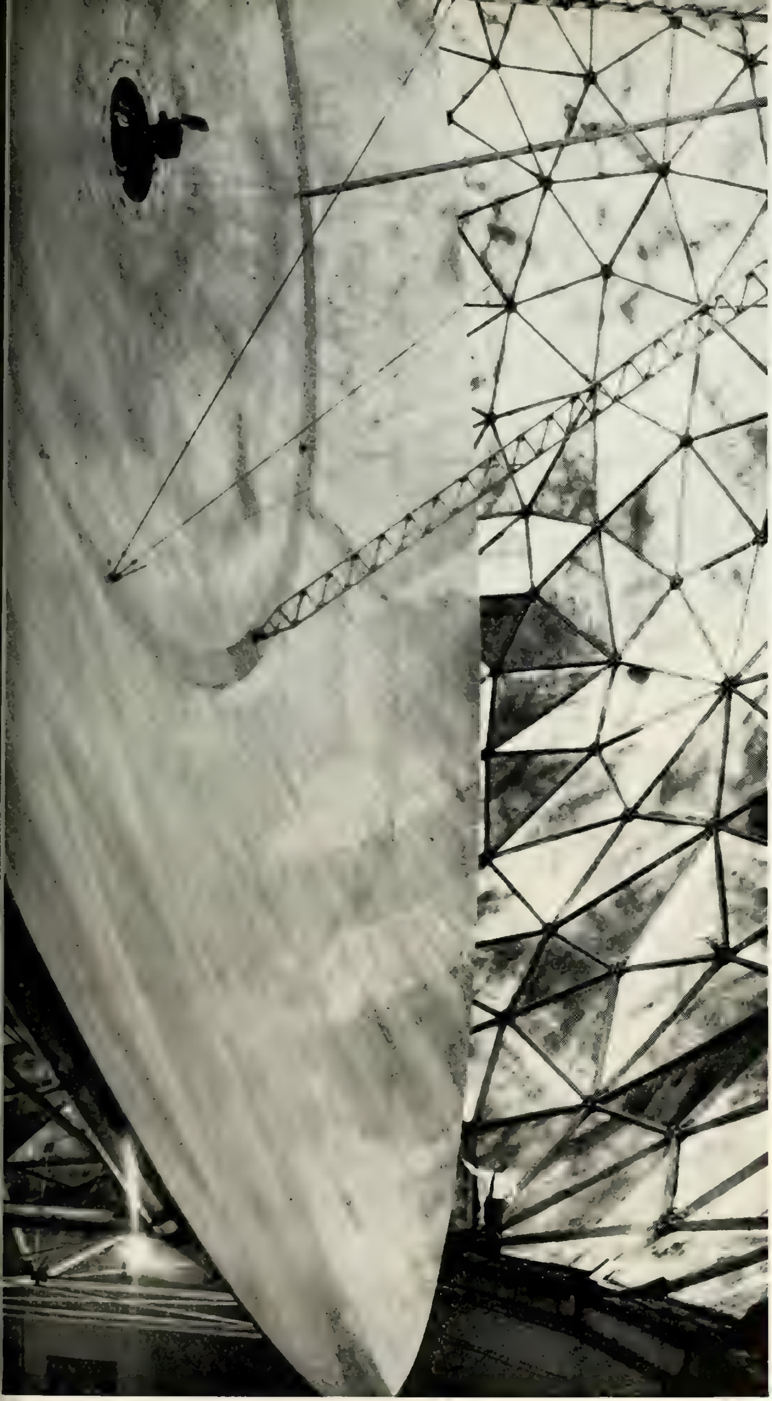
Concerning the $49-billion defense plateau, Mr. Murray commented: "We don't consider that an unhealthy market. Our company faces the future with confidence." Company chairman James S. McDonnell reported, meanwhile, that the indicated second fiscal quarter earnings of McDonnell Aircraft rose 27% on a 14% increase in sales—certainly a healthy sign.

This is what Dr. William C. Ellet, director of market analysis for Northrop Corp., has to say on the subject of the industry's future:

"I for one disagree with the conclusions of studies recently published by A. D. Little and Professor Wiedenbaum. It is my contention that both of these theses were based on a very narrow reading of American history in the first place, little or no analysis of foreign affairs, and the utilization of linear extrapolation for a non-linear situation. Moreover, the submission of the FY 1966 budget in terms of total obligational authority proves my point. In conclusion, I concur the defense budgets of the future may decline, but there is a finite point below which they will not fall. But more important than the quantitative level is the qualitative character of the mix. The changing structure will produce new and exciting opportunities for many firms in our industry. For all the reasons above, I cannot agree that the aerospace industry is moving into a major decline."

We are happy to note that all of this optimism is reflected in Wall Street stock averages. The question of industry confidence, we feel, is now settled.

William J. Coughlin



VARIAN-POWERED HAYSTACK RADAR TO MEASURE VENUS

...AND MORE DISTANT PLANETS

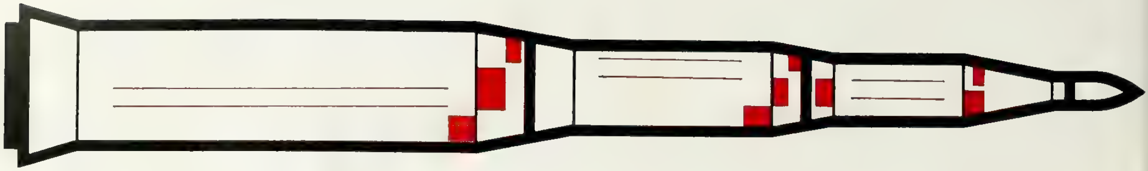
laystack, the new microwave research facility of MIT's Lincoln Laboratory, will soon begin radar studies of the planet enus and others. In addition to spanning the 29.5 million niles between Lexington, Massachusetts and Venus, the laystack system will provide valuable, practical guidance in he design of future high-performance microwave facilities. The radar phase of Haystack embodies a recently developed Varian five-cavity klystron, the VA-879 (driven by a Varian VA-617 TWT). Power output of the klystron is 100 kW CW at X-band. It has a gain greater than 50 db, a 3 db bandwidth of about 40 Mcps, and over-all efficiency greater than 40 per cent. Yet it is only 28 inches long.

Haystack is one more example of Varian's ability to power the world's most advanced microwave systems.

VARIAN associates TUBE division

Executive Offices: 611 Hansen Way, Palo Alto 10, Calif. ☐ Microwave Tube Group: Palo Alto Tube Division ☐ Solid State Products ☐ Bomac Division ☐ SFD Laboratories, Inc. ☐ Semicon Associates, Inc. ☐ Varian Associates of Canada, Ltd. ☐ In Europe: Varian A.G., Zug, Switzerland

Circle No. 12 on Subscriber Service Card



Minuteman Destruct System—85 ordnance components and 92 explosive interfaces developed by Aerojet.

How Aerojet achieves .999939 reliability in aerospace ordnance

Behind Aerojet's optimum performance: unmatched facilities, experience and a special four-point approach.

For more than a decade, Aerojet has been developing and producing advanced ordnance systems and components. Safe and arm devices, destruct and thrust termination systems, stage separation and missile component ejection systems and initiation systems are some of Aerojet's leading products. You'll find them on such missiles and spacecraft as Minuteman, Polaris and Ablestar. They all have one thing in common: uncommon reliability. Aerojet's unmatched facilities and staff are part of the reliability story. So are the following:

RELIABILITY THROUGH KNOWLEDGE

In the ordnance field, as in all others, there is no substitute for experience. No degrees, no diplomas are awarded in ordnance. The professional engineer in ordnance has to be a man of experience, qualified through thorough on-the-job training and many years of actual efforts in the field. Since 1953, Aerojet has been developing such men and such experience. Backed by the total aerospace capability of this leading, diversified company, and by more experience than any of its competitors, Aerojet's ordnance experts offer unduplicated authority in the production of complete ordnance systems or any components required.

RELIABILITY THROUGH CONTROL

During the development phase, Aerojet formulates manufacturing processes in exact detail to ensure the customer that his parts will perform with the same safety and reliability as the devices tested during development. Homogeneity of product is a primary requisite for statistical analysis and reproducibility of performance.

RELIABILITY THROUGH DOCUMENTATION

Each development program is thoroughly documented so that another quality manufacturer would have all the information necessary to produce the device to the same safety and reliability standards from Aerojet's documentation package.

RELIABILITY THROUGH TESTING

Reliability analysis and estimation begins with the product design. Using advanced statistical analysis techniques, Aerojet plans testing that demonstrates reliability from the outset. It's then firmly established and maintained through development and qualification. Aerojet strives to minimize costs in time and money; nothing is left to mere chance.

For a copy of report 1320-64(01)ER "Statistical Methods Application in Ordnance Development and Qualification," write to: Aerojet-General Corporation, 11711 Woodruff Avenue, Downey, Calif.

AEROJET
GENERAL TIRE
GENERAL

AEROJET-DOWNEY
Downey, California

FEBRUARY 15, 1965

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

HOUSTON PUBLIC
LIBRARY
Houston, Texas

Gov. Edmund G. Brown: Hard Tasks for Missile/Space Fir

Webb Says Mariner Will Beat Zond to M

SPECIAL REPORT—

California Looks at Advanced Technology . . 24

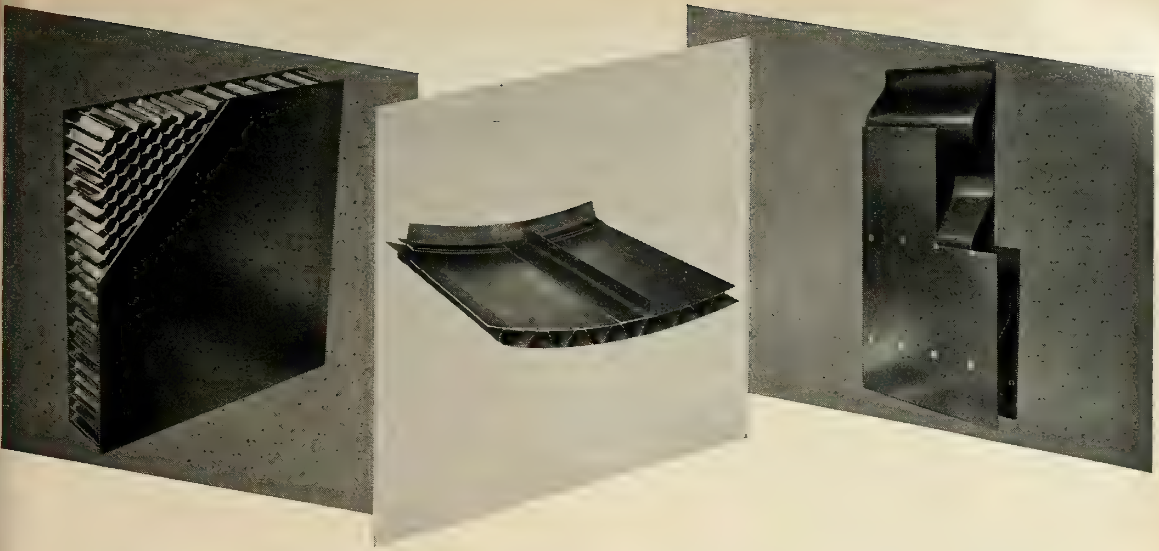
AN AMERICAN AVIATION PUBLICATION

if you had a 34″ forged ring of Inconel 718 . . .

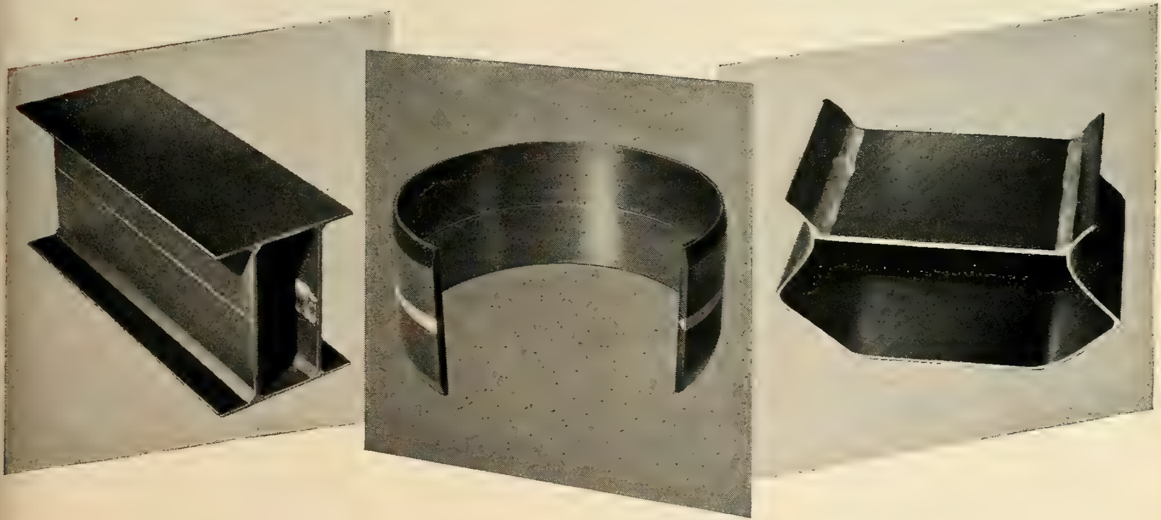
Ex-Cell-O could vertical turn recesses and grooves into it for you, precision grind and mill its faces to ± .0015″ TIR, and electrochemically machine its integral airfoil vanes within band tolerances of .004″. □ These operations on a turbine nozzle typify the broad range of machining capabilities available at Ex-Cell-O, where technicians work with zirconium, tungsten, tungsten-moly, pure molybdenum, molded graphite, Udimets, plastics, steels and other materials. □ Ex-Cell-O can meet your exacting specifications and deadlines, too, in prototype models or production quantities. □ Contact your Ex-Cell-O Representative or write for specifics. □ *Flight and Space Division, Ex-Cell-O Corporation, 1200 Oakman Blvd., Detroit, Michigan 48232.* 64-35 S

Flight & Space Division XLO EX-CELL-O CORPORATION

MAN AND MISSILES FLY HIGHER, FASTER AND SAFER WITH PARTS AND ASSEMBLIES BY EX-CELL-O AND ITS SUBSIDIARIES. XLO



which of these structural shapes are Beryllium?



ALL OF THEM!

Time was when this sort of formability and joining with beryllium was impossible. Not now. The structural shapes shown above are only a sampling of what has been done and what can be done. The techniques to produce them are here *now*. If beryllium is integrated into a design in its earliest stages, its full potential can be exploited. Think of the possibilities in *your* area for structural components of beryllium—the metal with the highest strength/weight ratio. How can *you* use beryllium to replace the "heavyweights" of the light metals field?

To find out how beryllium can meet your needs, or for technical assistance, write to The Beryllium Corporation, Dept. X-2, Box 1462, Reading, Pa. 19603

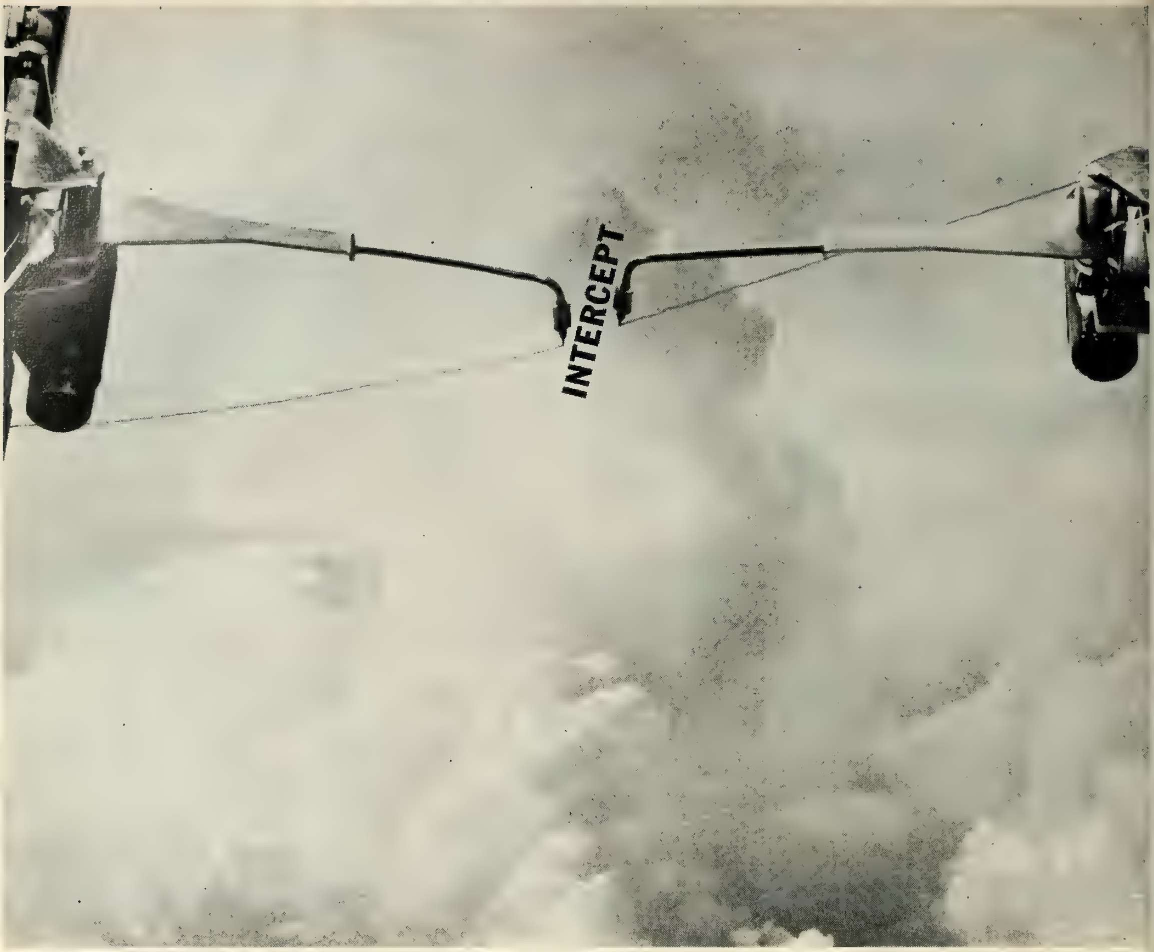
BERYLCO®

Developers and producers of extraordinary materials

BERYLLIUM • BERYLLIUM COPPER • BERYLLIUM NICKEL • BERYLLIUM ALUMINUM • BERYLLIUM OXIDE

← Circle No. 1 on Subscriber Service Card

Circle No. 2 on Subscriber Service Card



MISSILE TO MISSILE

Hit or miss? Bell Telephone research facilities at White Sands Laboratory, New Mexico, will have the answer in seconds.

This test—a simulated missile being intercepted by a simulated counter-missile—evaluates the intercept accuracy and kill probability of one of the nation's leading air-defense systems: the Army's Nike Hercules.

More than 25,000 tests like this have been made since 1955 including air-defense engagements. During this period only 300 live firings were needed to perfect the system.

Result: rapid low-cost development of a needed weapon of a very high reliability.

Because only the missile or target (or both) need be simulated to duplicate real conditions, this system can be almost wholly evaluated through a series of tests like these.

Another advantage to the nation's defense is that simulated targets can be made to perform well beyond the capabilities of physical targets available today.

Result: the system can stay a step ahead in defense weapon design.

The Nike Hercules System was developed by Bell Telephone Laboratories and produced by Western Electric and Douglas Aircraft Companies. The simulation equipment was developed and designed as an integral part of the test program.

It is this type of advance planning and development which builds economies into the nation's communications system, another vital bulwark of our defense.

Bell System
American Telephone and Telegraph Co.
and Associated Companies

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 7 February 15, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors
Charles D. LaFond................Electronics
William S. Beller................Engineering

Associate Editors
Lawrence J. Curran......Assistant Managing Editor
Heather M. David..................Space Medicine
Michael Getler........................Electronics
John F. Judge..................Advanced Materials
Robert L. Parker......................Copy Editor
Rex Pay...............................Electronics
Hal Taylor...................................NASA
James Trainor...........................Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach.................Art Director
Donald Strickland............Assistant Art Director
Suzanne Montgomery............Editorial Assistant
Sally Fosnight...................Editorial Assistant

BUREAUS
LOS ANGELES.....9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks..................Bureau Chief
NEW YORK..................20 East 46th Street
Michael Getler
CAPE KENNEDY ....507 Orange Ave.
Merritt Is., Fla.
MIDWEST ....423 N. Quentin
John L. Zimmerman ....Wichita, Kan.
PARIS..........................11 Rue Condorcet
Jean-Marie Riche
GENEVA..........................10 Rue Grenus
Frank G. McGuire

EDITORIAL ADVISORY BOARD
Dr. Peter Castruccio Alexander Satin
Conrad H. Hoeppner Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton...........National Sales Manager
Paul B. Kinney........Eastern Advertising Manager
Edwin J. Denker, Jr......Western Advertising Manager
Kenneth C. Blanchard.Marketing & Research Director
John N. Carlin..............Director of Circulation
Paddy Nelson................Circulation Promotion
R. Virgil Parker............Director of Production
Barbara Wiener........Advertising Services Manager

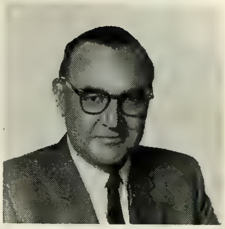
Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President.........................**Wayne W. Parrish**
Senior Vice President...............**Louis C. James**
Vice President......................**Fred S. Hunter**

THE COVER



California's Gov. Edmund G. Brown, initiator of his state's economic expansion plan, under which aerospace firms have been asked to devote their unique technologies to such problems as waste management, transportation and criminology. M/R's special report begins on p. 24.

FEBRUARY 15 HEADLINES

Navy Requests Poseidon Proposal from Lockheed 10
DOD Asks $1.945 Billion for Construction Purposes ... 10
NASA To Begin Ship-Launched Atmosphere Probes ... 10
Mariner Is Month Ahead of Russian Mars Spacecraft .. 15
FY '66 Budget To Buy Block I Apollo Flight Craft 16
Congressional Committees Back SNAP 8 Program 17
North American First in FY '64 NASA Contracting ... 18
First Titan III-X Flight Set for Summer of 1966 18
List of Top 100 Space Agency Contractors 21

SPECIAL REPORT—

California Pilot Plan Taps Advanced Technology Developed by Aerospace Firms 24

SPACE PROPULSION

Mass Expulsion Principle Foreseen Being Outmoded ... 32

MISSILE SUPPORT

Test Stand Assists in Polaris Sub Navigation 34

ADVANCED MATERIAL®

GE Elastomer May See Mars Re-Entry Shielding Use ... 40

DEPARTMENTS

Letters 7
The Countdown 9
The Missile/Space Week® 10
Technical Countdown . 23
The Industry Week 45
Contracts 46
Products & Processes 48
Names in the News . 52
When & Where 53
Editorial 54

48,600 copies this issue

COMMUNI
TIONS

Massive radio transmitters
to cut past the "Bamboo Curtain"
with the message of freedom.
"Walkie-talkies" to pierce the impen-
etrable jungle. "Stand-still" satellite
to bring television from across the
oceans. This is Hughes at work
in communications.

Sometime next year, in the Philippines, the United States Information Agency will go "on the air" with one of the most powerful radio stations on earth. Its purpose: To reach deep into China with the truth about the Free World.

The station will have ten giant, 250,000 watt transmitters now being built by Hughes. Contrary to most trends in electronics, its king-size parts must be handled by wrenches instead of tweezers. Tubes are big as bushel baskets, wires are like cables to handle the enormous power loads.

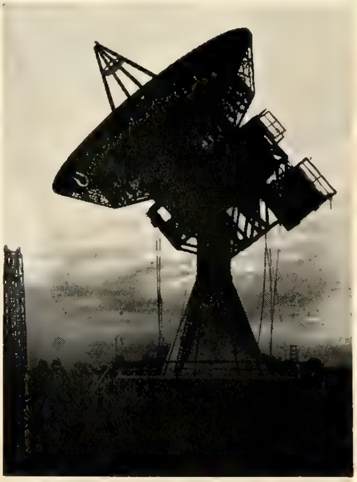
Paradoxically, although these giants need to send signals over thousands of miles, in some ways it is more difficult to make radios work just a few miles apart in dense jungle. Conventional types of man-carried radios can't cut through. High frequency radios, which "bounce" signals off the ionosphere, can. So today, our Special Forces troops are field testing a new Hughes "Manpack" high frequency single sideband radio. Manpack weighs in at just 25 lbs., is fully transistorized, has re-chargeable batteries, can send and receive both voice and telegraphy.

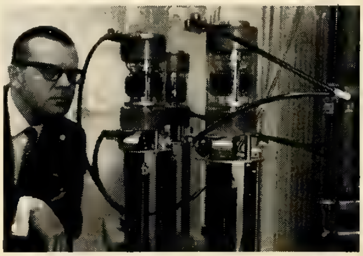
The ability to apply new knowledge to useful purpose whether in the jungle or in space is a Hughes hallmark. The Syncom satellite, created and built by Hughes, may well rank as one of the major communications advances of our time. Its unique ability to "stand still" over a point on earth permits uninterrupted television and telephone communications, 24 hours a day.

The first Syncom has amassed more communications time than all other such satellites combined. The "Olympic" Syncom, launched last fall, enabled you to see the opening of the Games "live" in the first trans-Pacific television presentation.

"Early Bird" the Syncom-type satellite built by Hughes for Comsat, will give the first uninterrupted TV and phone service 24 hours a day across the Atlantic Ocean. Just three such satellites could link all the nations of the earth.

Ground stations are the vital earth-based "ears" of satellites. Plans are under way to build a satellite ground terminal in Arkansas. It can be used for research,





HUGHES

CA-

for space communications research and other experimental activities including cooperative work with other countries. Its antenna will "see" satellites over both the Atlantic and Pacific Oceans.

These, and other communication achievements, such as traveling wave tubes for spacecraft, new systems using laser beams, speech compression techniques and new tropospheric-scatter systems—illustrate how Hughes is helping create a new world with electronics.

Engineers and scientists with interest in joining Hughes activities, are invited to inquire. Please write Mr. D. A. Bowdoin, Hughes Aircraft Company, Culver City 16, California. Hughes is an equal opportunity employer.

letters

Mars Parachutes

To the Editor:

Being actively engaged in studies of landing systems for a Mars probe, we at Cook Electric are very interested in the story "Northrop Advocates Parachute Landing System for Mars Voyager" (M/R, Dec. 7, p. 26), and agree that parachute systems currently offer the best possibilities. However, clarification of several statements regarding parachutes and materials is required.

Studies show that suitable descent conditions can be accomplished by deploying the first-stage chute at about 40,000 ft. A supersonic drogue chute would be required. The Hyperflo chute fits requirements perfectly. Far from needing further development, as stated in the referenced story, it has demonstrated its ability to perform over the entire range of Mach numbers through 4.0 in free flights and in wind tunnels through Mach 6. It is the only parachute design which has compiled a history of proper performance at speeds above Mach 2.2.

The use of a cluster of Ring Sail parachutes, as suggested by the article, may be desirable. However, if proven reliability is to be the criterion, a much more extensive test history exists for the "old reliable" cluster of solid flat canopies which has been used for many thousands of aerial deliveries by the Armed Services.

Regarding materials, use of silk and nylon has been shown to be impractical because of their degradation under probable thermal and chemical sterilization procedures. However, both Dacron and Nomex are suitable. In fact, it has been demonstrated that woven Nomex parachute materials actually can weigh less for the same strength than nylon.

Robert D. Turner
Senior Aerodynamist
Cook Electric Co.
Tech-Center Div.
Morton Grove, Ill.

Civil Service Dedication

To the Editor:

The Dec. 7 issue of M/R contained a letter from Mr. Henry Albert, Burbank, Calif., quoting a reported charge by President Johnson that "many top-level civil service management employees were mediocre and should be replaced now that government salaries were on a par with those of private industry." Mr. Albert then proceeded to list 10 steps which he said he recommended to "anyone aspiring to a top management job in civil service."

These were a series of proposed self-serving, arrogant, stupid, belittling, heavy-handed, inept time-serving actions which Mr. Albert intended as a sharp critique of the character and quality of Federal career employees.

The facts are that while President Johnson indeed is seeking top-quality personnel for key positions he also has been outspoken in his praise for the efficiency, effectiveness and devotion to duty of the overwhelming majority of all Federal employees—managerial, technical, craft, clerical all up and down the line.

For example, at a recent ceremony honoring a large group of Federal employees on the 10th anniversary of the Government Employees' Incentive Award Act, President Johnson declared that "I am convinced that we have career managers in government who are just as good as any managers in private business. I see evidence of this every day as our cost-reduction program produces improvements and savings." He pointed out that "this program has achieved much. In a single year it produced 118,500 employee suggestions which were adopted."

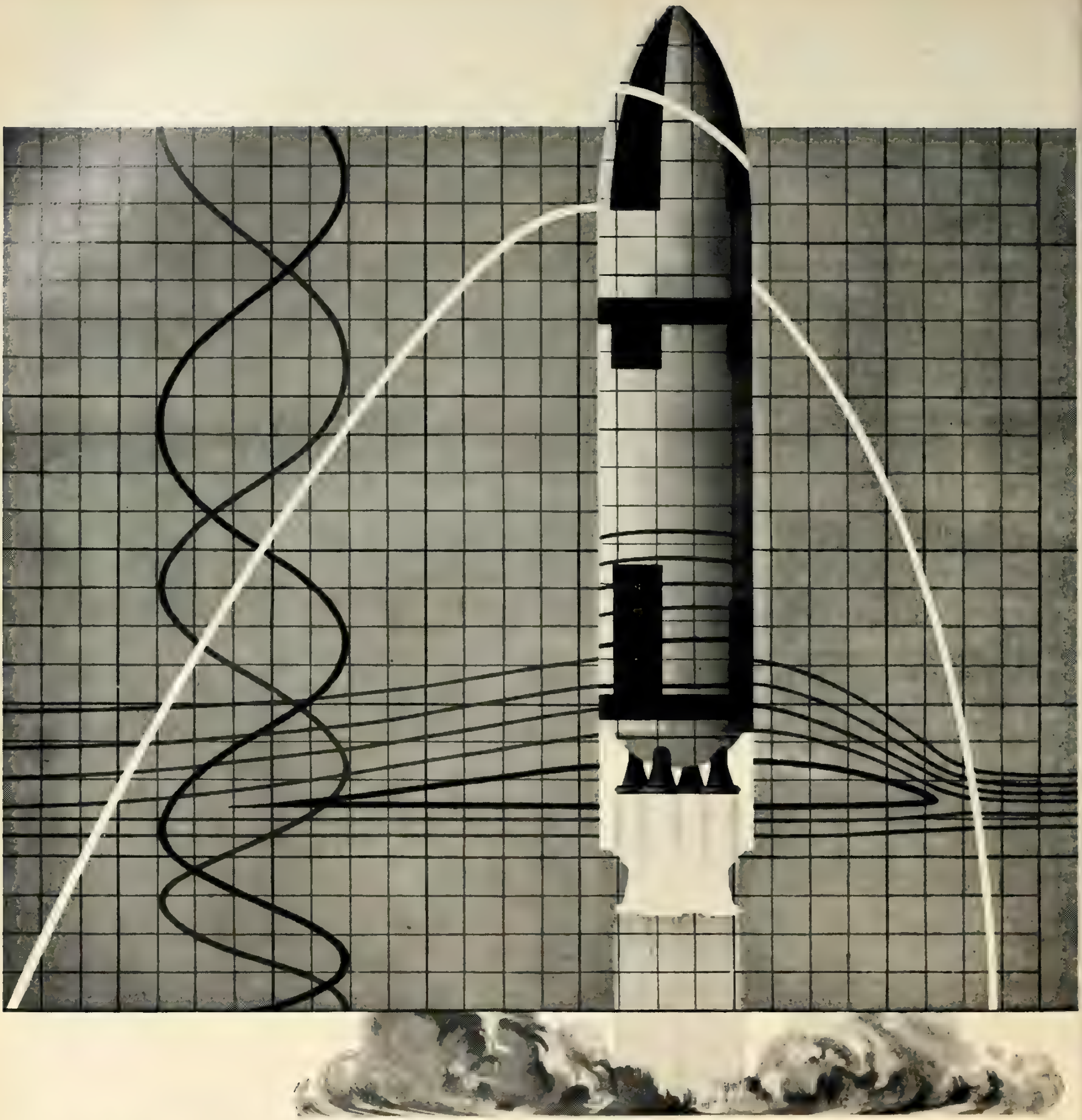
President Johnson is at one not only with other Presidents of the United States but with professional, business, and industrial leaders who know, from first-hand contacts, of the high level of efficiency of most Federal employees, at all grade level, and have so expressed themselves. In a recent article Mr. Clarence Randall, former board chairman of the Inland Steel Corporation, who has served successive Presidents in various posts of high responsibility, deeply deplored the "downgrading" of "Americans who are in government not as elected officers but as civil servants." In this connection—and it is particularly apropos to Mr. Albert's letter—Mr. Randall wrote that while progress against the name-calling progress vis-à-vis the civil service is being made "we probably will go on for some time yet, making automatic push-button responses to problems that merit thoughtful evaluation, substituting stereotyped epithets for reasoned argument, and employing incentive for persuasion."

Scattergun attacks upon American citizens who are devoting themselves to public service and to the vital tasks being carried out by the various departments and agencies of the Federal Government do a disservice to the nation. Such attacks inevitably add to the Government's already serious difficulty in getting and keeping qualified employees. Where would MISSILES AND ROCKETS be without their contribution?

It may be noted also, for the record, that government salaries are not now "practically on a par with those of private industry."

The comparability principle embodied in the recent pay laws has not been properly implemented. Federal salaries in key categories are lagging seriously behind business and industry, and recruitment and retention difficulties are a matter of mounting concern. The advocacy of shotgun blasts like the one published is one of the many reasons the devoted public servant has become a non-kissing, second-cousin citizen.

N. T. Wolkomir
President
National Federation
of Federal Employees
Washington, D. C.



LOOK AT LOCKHEED . . . IN AEROMECHANICS

Space systems one day will penetrate the atmospheres of Mars and Venus and safely re-enter the earth environment. When that happens, substantial credit will be due scientists and engineers at Lockheed Missiles & Space Company for significant contributions to these missions.

For example: Current work with cryogenic propellants has uncovered new technological problems in materials behavior, structures design, thermodynamics, and fluid mechanics. These require intense investigation. Protection of the payload against various hostile environments involves studies in determining planetary atmospheric characteristics, the search for adequate materials, the development of new analytical techniques.

Exploration of the vast "inner space" of the earth's oceans is an intriguing new frontier. Of particular concern at Lockheed is the development of advanced vehicle concepts and structures capable of withstanding severe, crushing pressure.

The Lockheed team that developed the POLARIS Fleet Ballistic Missile and the AGENA booster/satellite already has provided many answers. Engineers and scientists of all disciplines bearing on the solutions of these advanced problems are invited to submit their qualifications.

For a brochure that gives a complete *Look at Lockheed*, address: Lockheed Missiles & Space Company, Dept. 530, P.O. Box E504, Sunnyvale, California.

LOCKHEED
MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

AN EQUAL OPPORTUNITY EMPLOYER

The Countdown

WASHINGTON

McNamara's Own MOL Request Trimmed

Defense Secretary Robert S. McNamara originally requested $300 million in the FY 1966 DOD budget for the *Manned Orbiting Laboratory* (*MOL*), it has been disclosed. This was cut back to $150 million by the Budget Bureau, with President Johnson's approval, at a ranch-house conference. Action came after Sen. Clinton P. Anderson (D-N.M.) and his Senate Space Committee pressed for a study of the possibility of combining the *Apollo-X* and *MOL* programs.

Hawk ATBM Tests Rumored at White Sands

Unconfirmed—and unconfirmable—reports say that antimissile tests using the *Hawk* missile system are being conducted at White Sands Missile Range, N.M. The tests purportedly are being conducted against targets that simulate Soviet tactical ballistic missiles.

Voyager Mars Landers Envisioned in 1971

Two *Voyager* landers are likely to be launched in 1971 to place simple life-detection capsules on the surface of Mars, according to Homer E. Newell, NASA associate administrator for space sciences and applications. Newell says three 210-ft. DSIF antennas are expected to be operational around the world by '71. He believes it will also be possible to sterilize capsules 4-5 ft. in diameter, and therefore an attempt to land on Mars should be made at the earliest possible opportunity.

Four AOSO's Now Provided For

NASA's FY '66 budget request for the *Advanced Orbiting Solar Observatory* (*AOSO*) includes $19.2 million for the spacecraft, $5.9 million for experiments and $500,000 for ground operations. A total of four spacecraft are now included in the program, with first launch scheduled for 1969.

Little Astronomy Explorer Projected

One new satellite family now on the way is a small X-ray *Astronomy Explorer*, which NASA hopes to use to gather more information on stellar X-ray sources. Funding has been requested for the next fiscal year.

Navy Seeking Surveillance System

Navy's Applied Sciences Laboratory has asked industry for development and fabrication of a shipboard electro-optical system for area surveillance under low-level illumination conditions. System must be passive, capable of training in azimuth and elevation, and capable of resolving targets at ranges up to 10,000 yards.

IR for Fire Spotter Investigated

Army is interested in the feasibility of using an infrared detector to sense and locate ground fire from an airborne platform. A study of the potential of such a system will be conducted by Aberdeen Proving Ground with industry help.

Pioneer To Cost About $20.5 Million

NASA now estimates that the total cost of the *Pioneer* spacecraft program will be $20.5 million. Program calls for four solar-probe flights, alternating in trajectory so that two will head in toward the Sun and two will be directed away from it. Following an FY '66 request of $13.9 million, the agency expects to spend $4 million in FY '67 and beyond.

In Case You Missed It Earlier . . .

General Accounting Office saved the military services a total of $254.7 million, the AEC $3 million, and NASA $727,000 last year. This information was released in a 251-page document printed at Government expense, which compiles all the individual reports published last year. This is in addition to the GAO Administrator's Annual Report to Congress, published a few weeks ago, which also summarizes the year's work.

Urey Sees Lunar Dust Supporting LEM

There probably is 10-20 meters of finely divided material on the surface of Mare Cognitum, the lunar area photographed by *Ranger VII,* says Professor Harold C. Urey. The famed scientist, speaking in Denver at the Symposium on Unmanned Exploration of the Solar System, added that some maria may have dust layers a kilometer deep. But he believes such material can support a spacecraft because of the adhesive forces that appear between dust particles in a vacuum. He suggested that *Apollo* astronauts should head for a crater about 1,000 meters in diameter, because this might reach down to primitive lunar rock bearing traces of material from living organisms that appeared billions of years ago on Earth.

Mariner Solar Flare Data Still in Study

NASA expects to have to wait until April before providing any meaningful interpretation of a recent encounter by *Mariner IV* with an apparent solar flare. At the moment, all the space agency really knows is that on Feb. 5 some of the experiments on board the Mars-bound spacecraft indicated about a 200% increase in intensity. This seems to have been caused by a solar flare, but its magnitude and direction are still undetermined.

INDUSTRY

Seven Firms Get ASMS Study Extensions

Navy has extended until July pre-project definition studies by seven contractors of its proposed *Advanced Surface Missile System* (*ASMS*), according to the office of Sen. Warren Magnuson (D-Wash.). Raytheon, Sperry Rand, GE, Boeing, Westinghouse, RCA and Hughes won the $500,000 contracts last year, and had been scheduled to deliver the studies last month. If approved, the program would replace the *Terrier-Tartar-Talos* defensive missiles on ships of the line, and hence could be one of the biggest missile programs in sight.

Boeing To Test Lunar Orbiter Model in August

First complete ground-test model of the *Lunar Orbiter*, being developed for NASA by Boeing's Aerospace Div., is due to enter the division's huge thermal-vacuum chamber at Kent, Wash., in August. An early, partially complete test model already has been tested in an RCA chamber at Princeton, N.J., and a second has been dynamic-tested at the Boeing Developmental Center in Seattle. First flight model of the spacecraft is to be delivered May 7, 1966.

INTERNATIONAL

French Guiana Base To Be Operational in 1968

France is moving to finish development of its launch base in French Guiana, on the north coast of South America, in early 1968. The facility will replace the present complex at Hammaguir, Algeria, which the French must evacuate in July, 1967. Present plans are to make the new base available for use by other nations and international organizations.

Poseidon RFP Issued

Navy has officially asked Lockheed Missiles & Space Co. to submit a proposal for development and production of the *Poseidon* missile system, according to L. Eugene Root, the company's president. Following submission of the proposal, the company will negotiate a contract for the project definition phase.

Lockheed has requested proposals from five companies for development of the solid propellant motors for the two-stage missile. These companies are: Aerojet-General Corp., Hercules Powder Co., Thiokol Chemical Corp., United Technology Corp. and the Rocketdyne Div. of North American Aviation.

Lockheed's proposal for the sub-launched missile is expected to be submitted to the Navy in March.

NASA Probes OSO Failures

Scientists at Goddard Space Fight Center are looking into the apparent failure of two of the eight scientific experiments launched aboard the *Orbiting Solar Observatory (OSO) II* on Feb. 3.

Six of the experiments are transmitting excellent data, NASA spokesmen said, but the ultraviolet scanning spectrometer and the ultraviolet spectrophotometer sent back irregular data. They have been turned off to prevent further damage.

A program to determine the nature and probable cause of the irregularities is underway and tests of the two experiments will probably be made this week.

Ranger Photos Distributed

NASA is distributing the first of three sets of *Ranger VII* photographs of the Moon's surface for interpretation by leading astronomers and other interested scientists in 38 countries.

The set contains 199 photographs taken by the spacecraft's "A" camera last August. Later, two more sets of photographs taken by the other cameras aboard will be distributed. Scientists receiving the photos will be asked to make their interpretation available to the space agency before July, when a compilation of the analyses is planned.

Upper Atmosphere Shots Set

A three-month Mobile Launch Expedition for conducting upper atmosphere experiments from the deck of a ship is planned to begin this week.

NASA will launch a series of 50 or more scientific experiments from the USNS Croatan, a converted aircraft carrier, off the west coast of South America. Solid-fueled *Nike-Apache* and *Nike-Cajun* sounding rockets will carry 50-lb. payloads to altitudes exceeding 100 mi. In addition, some 40 or 50 *Arcas* and *Hasp* weather rockets will be fired to obtain meteorological data.

Saturn V S-II Stage Completed

THE FIRST S-II stage for NASA's Saturn V Apollo booster is shown in its test stand after being completed at North American Aviation, Inc.'s Space and Information Systems Div., Seal Beach, Calif., facility. The stage is the first space booster to be assembled vertically by NAA's "building-block" system.

Military Construction Up

DOD has requested $1,945,497,000 for military construction in FY 1966—almost double the $984.2 million total obligational authority requested last year. However, in missile/space terms, the increase is more apparent than real. Family housing, both new construction and maintenance, accounts for some $735,600,000 of the total.

Covering construction at more than 300 installations throughout the world, the request "will support key defense missions, such as our strategic offensive and defensive forces and our general support forces," the Defense Dept. said.

Individual service requests were:

—Army: Inside U.S., $305,020,000; outside U.S., $76,559,000; and unspecified, $10,000,000.

—Navy: Inside U.S., $240,944,000; outside U.S., $62,649,000; and unspecified, $10,000,000.

—Air Force: Inside U.S., $280,944,000; outside U.S., $92,821,000; and unspecified, $10,000,000.

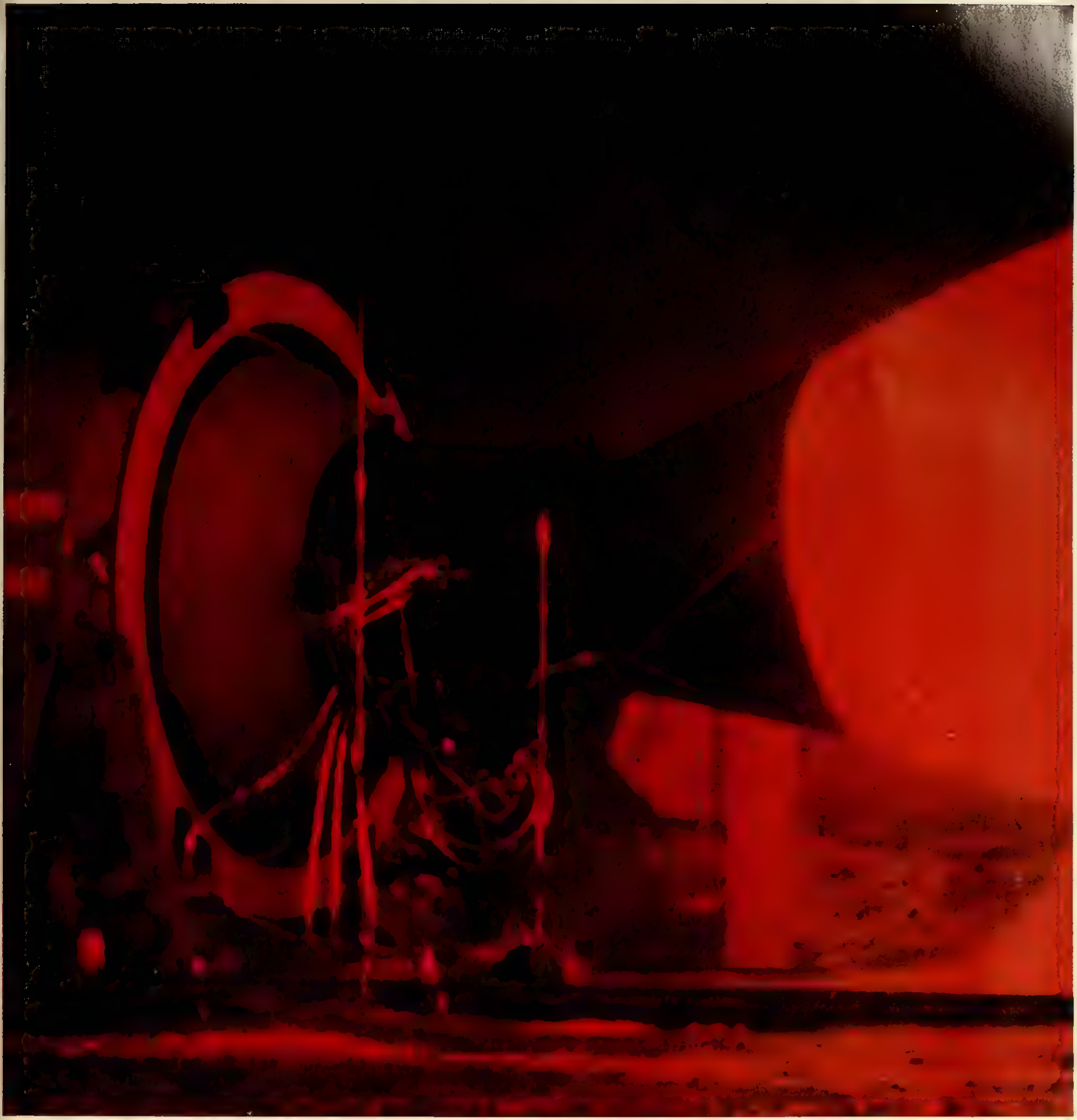
—Defense agencies: Inside U.S., $26,507,000; outside U.S., $3,688,000; and unspecified, $70,000,000.

Reserve components are earmarked to receive $21,200,000 for construction in the U.S.

Funds for strategic retaliatory forces, while including no funds for silo construction, do provide for upgrading the previously authorized *Minuteman* silos and improvement of *Titan II* sites. Money is also sought to permit realignment and to insure safe and continued operation of the manned bomber force.

In the continental defense forces category, funds are asked for site relocation and improvements of the *Nike-Hercules* as well as for providing the batteries with fallout protection.

Major portions of the Army's research and development facilities



The big one did it!

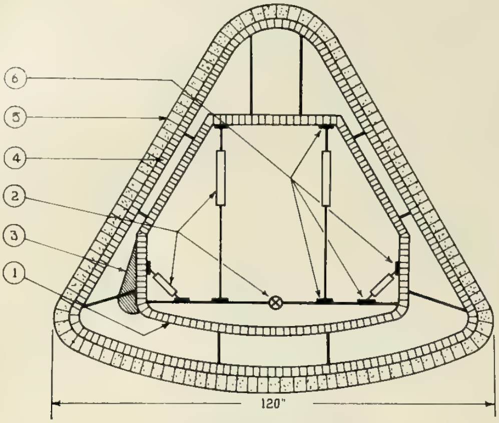
Largest, most powerful solid space booster tested to date generates 1.4 million lbs. thrust over two-minute burn time

In the first of Thiokol's three great assaults in the conquest of space based on solid rocket technology, the company has fired its first 156″ segmented motor. The firing reaffirmed the large segmented motor concept, demonstrated practical scale-up of world's largest omniaxial gimbaled nozzle, and advanced an approach to space booster ignition—the launcher-retained system. The space age now awaits assaults two and three as Thiokol readies still bigger solid boosters for imminent test—a three-million-pound thrust 156-inch motor and the 260-inch booster motor which will ultimately produce over 6,000,000 pounds of thrust. These motor demonstrations are part of the large space booster program conducted jointly by the Air Force Systems Command, Space Systems Division, and NASA.

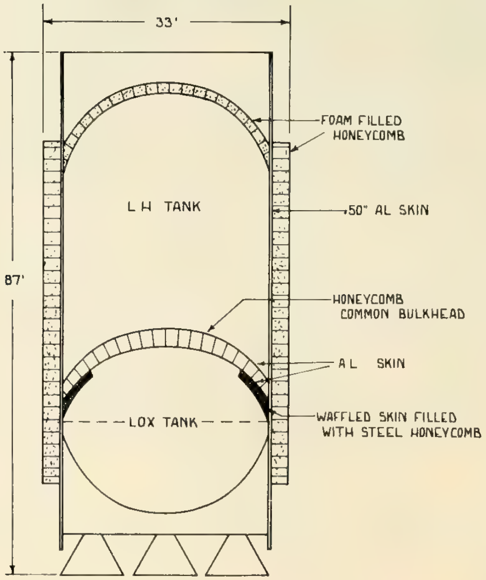
Thiokol
CHEMICAL CORPORATION
AEROSPACE CENTER: OGDEN, UTAH

Circle No. 4 on Subscriber Service Card

WRITE...



FOR THE
APOLLO-HONEYCOMB
STORY


33'
87'
L H TANK
LOX TANK
FOAM FILLED HONEYCOMB
.50" AL SKIN
HONEYCOMB COMMON BULKHEAD
AL SKIN
WAFFLED SKIN FILLED WITH STEEL HONEYCOMB

The article describes how honeycomb materials will provide efficient design solutions for ablation, insulation, energy absorption and strength/weight problems. Some of the solutions are quite unusual. Write to:

HEXCEL® PRODUCTS INC.
World leader in research and manufacture of honeycomb core materials.
Executive Offices: 2332A Fourth St., Berkeley, California 94710

funds will be spent on the *Nike-X* missile system.

A science material laboratory at Wright-Patterson AFB, Ohio, an Electronics Laboratory at Griffis AFB, N.Y., and the first increment for construction of a *Titan-III* complex at Vandenberg AFB, Calif. head the list of Air Force R&D construction projects.

The entire $3,688,000 earmarked for Defense agencies construction outside the continental U.S. is to be spent for facilities on Johnston Island. It is carried as chargeable to the Defense Atomic Support Agency and is most likely in support of continuous readiness to resume nuclear testing.

Not listed in the request, but probably included in the unspecified funds, are monies for the installation of over-the-horizon radars. This installation was reported as proceeding by President Johnson in his Defense Message to Congress.

Biomed Experiments Discussed

Scientists and space organization representatives from 24 countries have been invited to meet with NASA to discuss and propose biomedical experiments for Projects *Apollo* and *Gemini.*

The conference will be held at the Manned Spacecraft Center April 22 and 23. Dr. W. Randolph Lovelace II, director of space medicine, will be in charge.

Both of NASA's manned flight programs are open to proposed experiments by the world scientific community.

Shots of the Week

The Air Force on Feb. 3 "ripple-launched" two *Minuteman* ICBM's from Vandenberg AFB, Calif. Both were launched from silos, the second within minutes of the first. The test was the second in which two *Minutemen* were fired in such close order.

- A *Polaris A-3* launched from the nuclear submarine Sam Rayburn on Feb. 8 represented the sixteenth consecutive success for that missile. The Rayburn was submerged off the coast of Cape Kennedy.
- An Air Force Strategic Air Command crew from Whiteman AFB, Mo., successfully launched a *Minuteman* ICBM from Vandenberg AFB, Calif., on Feb. 9.

Hawks Go to Viet Nam

The Army's *Hawk* anti-aircraft missile may get the opportunity to

Circle No. 3 on Subscriber Service Card

prove its mettle under actual combat conditions in Viet Nam.

A battalion of the missiles has been deployed to Da Nong in northern South Viet Nam in anticipation of possible Communist Chinese MIG operations in the near future.

Cooper, Conrad To Pilot GT-5

Astronauts Leroy Gordon Cooper and Charles Conrad, Jr., have been named the crew for NASA's *Gemini-Titan 5* flight, now scheduled to last seven days.

The space agency named pilots Neil H. Armstrong and Elliot See as backup crew for the flight, which is planned for the fourth quarter of this year.

Some space medicine experts at Manned Spacecraft Center indicated that Cooper's selection was additional proof that NASA does not feel he was adversely affected by long-term weightlessness in previous space flights. Cooper himself expressed some doubts that the space agency fully believed Russian reports of the extreme after-effects of space flights after more than two days in orbit.

New Computer Line Shown

A versatile, building-block computer line was announced in Washington last week by the Electronic Data Processing Div. of Honeywell, Inc.

Offering what the company termed significant "cost/performance" advantages, the line includes five progressively more capable data processors and a large number of peripheral equipment options. The new line is based on the H-200 Honeywell computer and is to be marketed as the "200 Series."

Tagged "dimensional data processing" by Honeywell, the 200 series is geared to more sophisticated user needs and includes add-on building blocks to allow the user to expand his computer capacity as his data processing demands increase.

Be Lieu Suceeds Fay

Kenneth E. Be Lieu was named Under Secretary of the Navy last week, succeeding Paul B. Fay.

Be Lieu, a much-decorated former Army officer and one-time staff member of the House Armed Services Committee, has served for the past four years as Assistant Secretary of the Navy (Installations and Logistics). Graeme C. Bannerman, Deputy Assistant Secretary of Defense for procurement, will replace Be Lieu.

QUICK AS A WINK!

BUT WOLLENSAK FASTAX IS 300 TIMES QUICKER

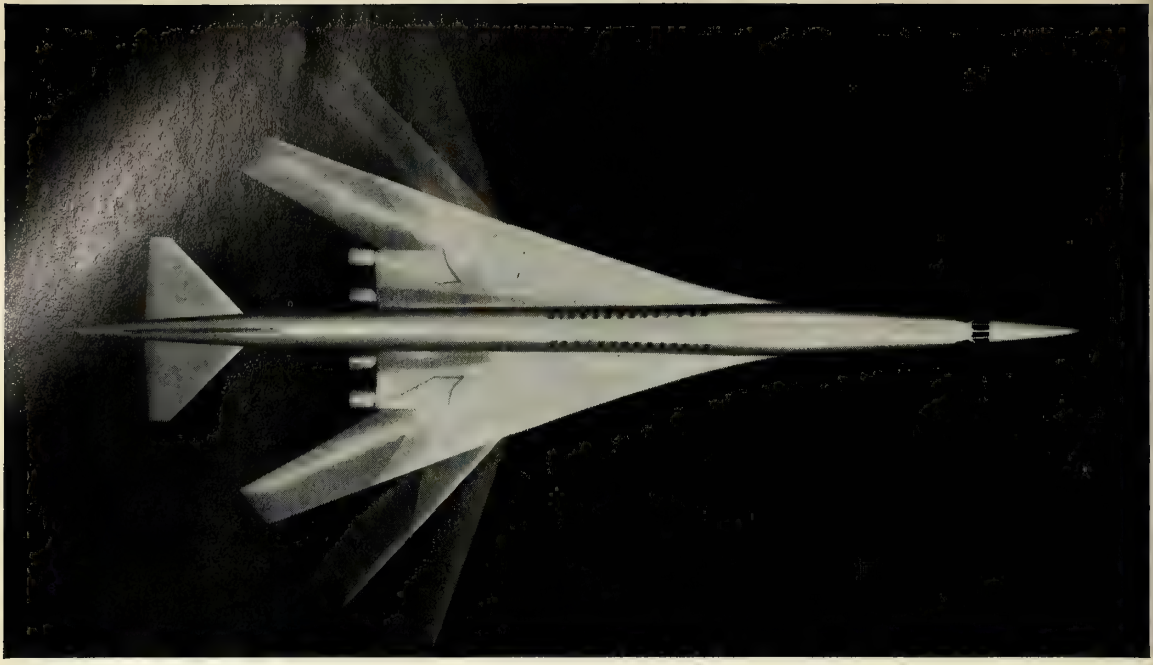
That's why a Wollensak FASTAX High Speed Motion Picture Camera can help solve your design, development, manufacturing and testing problems. When action too fast for the eye to see is stopped cold with FASTAX, there is no question what is happening. The blur of speed is gone.

FASTAX is today's indispensable tool for research and development engineers. FASTAX camera studies are helping solve motion, vibration, stress problems in electrical, mechanical, chemical, medical and physical fields. The use of high speed photography is limited only by the ingenuity of the engineer with the problem to be solved.

WRITE today for free Data File on Wollensak FASTAX motion picture, oscillo-streak or combination cameras, processing equipment and accessories. Inquiries invited.

Photographic Equipment And Optics Division 3M COMPANY
601 Hudson Ave., Rochester, N.Y. 14621

Circle No. 5 on Subscriber Service Card



Enjoy a dynamic, long-range career with the world leader in jet transportation

The Boeing Company, today's world leader in the field of jet transportation, is already at work on the next generation of jets — including giant logistics aircraft, supersonic passenger liners and other manned aircraft systems. Boeing's current business backlog is approximately $2 billion, of which some 60% is in commercial jetliner and helicopter product areas. The remainder is in military programs and government space flight contracts. This gives the company one of the most stable and diversified business bases in the aerospace industry.

Experienced engineers and scientists who look toward expanding the scope of their careers in this dynamic field will find professional challenge and unique advancement opportunities with Boeing's Airplane Division. Immediate openings are available at both Renton (near Seattle), Washington, and Wichita, Kansas, for qualified graduates in engineering, physics, mathematics, business administration, operations research and production management. Specific areas of assignment are listed at the right.

Salaries are competitively commensurate with your experience and educational background. Moving and travel allowances are paid to newly hired personnel. Boeing is an equal opportunity employer.

Send your resume, today, to:

Mr. Thomas Sheppard, *Airplane Division*
The Boeing Company, P.O. Box 707-BAU,
Renton, Washington 98055

or

Mr. Gerald Caywood, *Airplane Division*
The Boeing Company, Dept. BAU,
Wichita, Kansas

BOEING
AIRPLANE DIVISION

Other Divisions: Aero-Space • Turbine • Vertol
Also, Boeing Scientific Research Laboratories

DESIGN ENGINEERING
- Structural
- Hydraulic
- Air Conditioning & Pneumatic Systems
- Aircraft Control
- Power Plant
- Fuel Systems

DEVELOPMENT ENGINEERING
- Structural Dynamics
- Stability & Control
- Flight Control Systems
- Fatigue Analysis
- Loads Analysis
- Stress Analysis
- Hydraulic and Electrical Systems
- Weights
- Environmental Control
- Metallurgy
- Non-Metallic Materials
- Antenna Systems
- Support Equipment/ Facilities (Electronics)
- Propulsion
- Navigation and Guidance Systems
- Radar Technology
- Military Operations Analysis
- Weapons Delivery Systems
- Flight Operations Instrumentation
- Electronic Countermeasures
- Human Factors
- Costs & Schedules
- Technical Writers

TOOL ENGINEERING
- Tool Design
- Tool Liaison

Zond a month behind . . .

Webb Says Mariner Winning Mars Race

NASA chief also says U.S. craft will come nearer planet than Soviet counterpart; space agency discloses which areas will be photographed

by Hal Taylor

A HIGH-LEVEL Administration official reports that this country's *Mariner IV* spacecraft will beat the Soviet Union's *Zond 2* in the race to explore Mars.

NASA Administrator James E. Webb said that the space agency's spacecraft is leading its Russian counterpart "perhaps by as much as a month."

He also said that *Mariner IV* will "fly closer to Mars than the Russian spacecraft." He based his statements on tracking information compiled by Nuffield Radio Astronomy Laboratory at Jodrell Bank, England. It also is assumed that he has access to secret U.S. tracking reports.

Mariner IV was launched Nov. 28, 1964. Two days later, the Russians announced the launching of their *Zond 2* spacecraft. Since that time, they have reported that it has had communication difficulties.

If *Mariner IV* does get to Mars first, it will mark only the second time that the U.S. has topped the Soviet Union in a space-age first. The only other major triumph for this country occurred on Dec. 14, 1962, when *Mariner II* radioed back to Earth dato on *Venus'* atmosphere and temperature.

Webb's forecasts were made in Detroit recently when he was awarded an honorary Doctor of Humanities degree from Wayne State University. His comments were made public as NASA announced the areas of Mars which will be photographed by *Mariner* as it passes the planet on July 14, 1965.

- **Picture sequence**—If *Mariner* is still operating normally, the first picture will be taken when the spacecraft is about 8,400 mi. above the Martian surface. Its television camera will sweep an area some 4,000 mi. long from the northern hemisphere, where it will be fall, down through the southern hemisphere, which will be in the spring season.

When the first of the 21 pictures is taken, the spacecraft will be looking down at the northern Martian desert, Amazonis. The camera's coverage will then sweep southeast below the Martian equator covering the Mare Sirenum, the southern desert Phaethontis, the Aonius Sinus and into the planet's terminator or shadow line.

The last picture will be taken when the spacecraft is about 6,300 mi. above the Martian surface.

The picture-taking portion of the flight will begin about 8:25 p.m. EST. Some 25 minutes later, the final picture will be taken; after another 21 minutes, the spacecraft will make its closest approach to Mars at an altitude of about 5,400 mi.

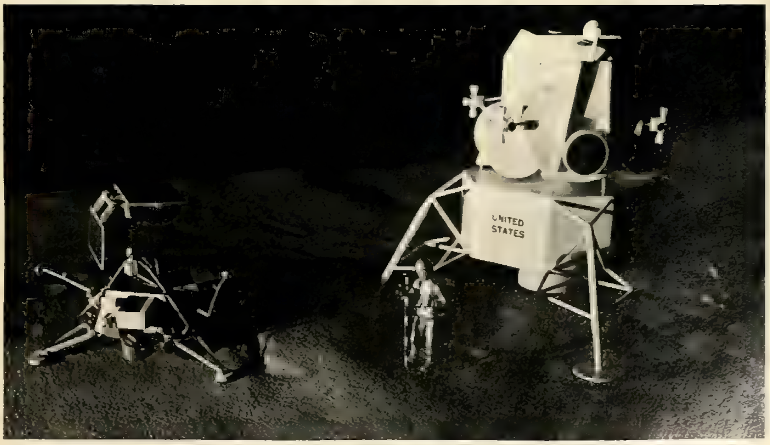
- **High resolution**—The maximum ground resolution will occur near the middle of the photograph sequence, when the camera is pointing nearly straight down toward the area of Mare Sirenum. At this point, each photo will cover an area approximately 150 mi. on a side and is expected to resolve prominent surface markings as small as two miles across.

The photographs will be stored in digital form on tapes and will be sent back to Earth after *Mariner* passes beyond Mars.

Each picture will consist of about 250,000 bits of data and will be recorded at 10,700 bits per second. Since the transmission rate is eight and one-third bits per second, the playback sequence will take about eight hours. This will be followed by one and a half hours of engineering data on the condition of the spacecraft; then the next picture will be transmitted. It is planned to repeat the playback of the pictures at least twice.

Target areas for the picture-taking were outlined by the space agency in a notice requesting amateur and professional astronomers to observe the areas with ground-based telescopes. NASA said that the areas can be seen a number of times over the next several months—both before and after the closest approach of Mars to Earth in early March.

The general areas on Mars to be photographed were determined at the time of the midcourse correction to *Mariner's* flight path on Dec. 5. One requirement for the midcourse maneuver was to time *Mariner's* encounter period with Mars to coincide with the tracking period of the Goldstone station of the Deep Space Network in the Mojave Desert. This ensures maximum communication and command coverage. ■



Probable Shape of Moon Landing Area

MODEL OF SMALL area of lunar surface, based on region covered by final P camera picture from Ranger VII, built by photometric scaling process developed by Dr. E. E. Shoemaker, chief Ranger experimenter. LEM, Surveyor models are same scale.

In FY '66 request . . .

First Apollo Flight Hardware Funded

NASA'S FISCAL YEAR 1966 funding request of $550 million for the *Apollo* spacecraft's Command and Service Modules will pay for the first Block I flight vehicles, scheduled to fly on the *Saturn IB* booster in 1966.

In addition, the budget request will fund two more flight vehicles and five production test spacecraft.

Manufacture of the Block II spacecraft, which will be used for rendezvous missions with the *Saturn IB* and lunar flights with the *Saturn V* booster, will also be initiated.

Milestones expected to be reached with FY '66 funding in the Lunar Excursion Module (LEM) development program include completion of design and engineering and component development tests—plus the beginning of a qualification test program on prototype flight hardware.

Dynamic tests of the LEM/*Saturn V* configuration will be continued at the Marshall Space Flight Center. Two additional LEM test spacecraft will be delivered. Manufacture of the first flight spacecraft will continue. Five more flight vehicles will go into production.

- **Saturn IB progress**—In the *Saturn IB* program, the major effort in the next fiscal year will include the launching of the first two flight boosters. Two additional flight vehicles will be delivered, and the fabrication, assembly and checkout on the fifth and sixth flight vehicles will be completed.

By the end of the year, the space agency expects to begin checkout of the seventh flight vehicle and assembly of the eighth booster. At the same time, 38 H-1 engines will be delivered.

Seven J-2 engines for the booster's second stage also will be procured.

The $5-million request for an integrated *Saturn IB/Centaur* launch vehicle will be used for design studies and the preparation of plans leading to hardware development.

The booster, NASA said in a presentation to Congress of additional budget information, will provide an Earth-to-Moon transfer payload capability of approximately 9,500 lbs. NASA says the three-stage vehicle can be used for a variety of launch roles, including highly eccentric, multiple-launch *Orbiting Geophysical Observatories*, advanced technological satellites and lunar and planetary missions.

- **Advanced Apollo**—In discussing its $50-million request for the *Apollo* Extension systems, NASA said the time had now come to begin the detailed program definition phase.

Advanced development and final design activities during FY '66 will be devoted particularly to modifications of electrical-power, reaction-control and life-support subsystems and components necessary to extend capabilities to four to six weeks in Earth orbit, and up to two weeks of lunar staytime. The agency told Congress that early identification and development of experiments are essential to flight-mission planning.

"Categories of experiments already being identified for advanced development funding are related to the investigation of zero gravity and artificial gravity; to meteorology; to geological and geophysical experiments related to the Earth and to the lunar surface; to astrophysics; and to the performance of future missions. Particular emphasis during FY '66 will be placed on the advanced development of the actual devices proposed for the conduct of experiments during the early mission opportunities . . ." ■

BREAKDOWN OF NASA MANNED SPACE FLIGHT R & D BUDGET REQUEST

(millions of dollars)

PROGRAM	FY'65	FY'66
GEMINI		
Spacecraft	165.3	122.7
Launch vehicles	115.4	88.6
Support	27.7	30.8
TOTAL	308.4	242.1
APOLLO SPACECRAFT		
Command and Service Modules	525.0	550.0
Lunar Excursion Module	226.0	270.0
Guidance and navigation	80.0	108.7
Integration, reliability and checkout	44.4	69.3
Spacecraft support	117.05	120.84
TOTAL	992.45	1,118.84
SATURN I		
S-I stage	9.3	.7
S-IV stage	19.5	1.5
Vehicle support	23.75	2.2
TOTAL	55.45	4.4
SATURN IB		
S-IB stage	67.6	75.3
S-IVB stage	47.0	73.3
Vehicle instrument unit	40.0	39.9
Ground support equipment	36.7	9.7
H-1 engine procurement	12.4	9.7
J-2 engine procurement	11.4	14.0
Vehicle support	41.05	47.8
Saturn IB/Centaur design studies	5.0	5.0
TOTAL	261.15	274.7
SATURN V		
S-IC stage	235.35	273.3
S-II stage	174.06	237.5
S-IV stage	141.6	177.19
Vehicle instrumentation unit	81.0	84.2
Ground support equipment	62.7	87.67
F-1 procurement	68.1	99.0
J-2 procurement	57.96	87.8
Vehicle support	143.66	189.78
TOTAL	965.0	1,236.5
ENGINE DEVELOPMENT		
H-1 engine	4.8	4.8
RL-10 engine	14.4	1.9
F-1 engine	54.4	52.5
J-2 engine	46.2	45.5
Propellants and related engine support	33.59	36.0
TOTAL	153.40	140.70
APOLLO MISSION SUPPORT		
Systems engineering	41.0	41.0
Launch operations and instrumentation	20.57	37.24
Mission control systems	38.5	36.4
Apollo space operations	25.35	37.0
Supporting development	53.9	70.6
(Apollo extension systems)	(14.0)	(48.0)
TOTAL	179.32	222.24
ADVANCED MISSIONS PROGRAM	26.0	10.0

At AEC budget hearings . . .

SNAP 8 Support Gathers Momentum

System's future to be decided by Joint Committee on Atomic Energy, Senate and House space committees; fund cuts hit

by Heather M. David

A DECISION on the future of the SNAP 8 space power reactor system will soon be made by the Joint Committee on Atomic Energy and the Senate and House space committees, following submission of NASA's plans to shift approximately $3 million of its FY 1965 funds to continue some testing work in 1966.

Sen. Clinton P. Anderson (D-N. Mex.), chairman of the Senate Space Committee and a member of the JCAE, sharply questioned the action of the Budget Bureau in disallowing NASA's funds for the program, which is jointly supported by NASA and AEC. He said he thought many of the members of the JCAE felt that the SNAP 8 should be brought to a full ground systems test. As yet, no SNAP system with turbogenerator conversion equipment has been tested with both the nuclear reactor and conversion cycle operating together.

AEC and NASA witnesses at last week's AEC budget authorization hearings, including NASA Administrator James E. Webb and NASA/AEC Joint Program Chief Harold Finger, indicated it would cost about $50 million more in the next two years to complete the ground systems test. About $100 million has already been spent on the program by the two agencies.

NASA's request to the Budget Bureau for FY '66 was $16 million, but was completely deleted for economy reasons, according to Webb. The AEC asked for $10 million more than the $9.5 million granted it for the reactor portion, AEC Chairman Glenn T. Seaborg said. For FY '67, the last year of the program, NASA would have required $8 million, and AEC from $15-20 million, the witnesses disclosed.

- **Give AEC funds?**—The possibility was raised that NASA's conversion equipment portion of the program might be funded in the form of an addition to the AEC budget, with the work turned back over to NASA. This would meet the objective of keeping the space budget at the $5.26-billion level determined by President Johnson.

Webb disclosed that in addition to the SNAP 8 briefing, which will be given as soon as possible, NASA plans to make a case for the M-1 and 260-in. solid booster programs before the House and Senate space committees. All were deleted by the Budget Bureau in NASA's final budget.

But Sen. Anderson said that although he favors continuing SNAP 8, he thinks the M-1 program "should be cut off right now" and that perhaps the 260-in. solid program should never have been continued last year after the Defense Dept. first dropped it from its budget.

Other committee members, notably Sen. Richard B. Russell (D.-Ga.), have spoken strongly in favor of the program and the committee has promised to hear out any case for all three programs (M/R, Feb. 8, p. 12).

- **Flight test**—One program the JCAE almost singlehandedly has managed to nurture into some fruition is the SNAP 10A system, which produces 300 watts with a thermionic conversion cycle. Although the Administration had decided to cut this program off just before a flight systems test, the JCAE, after applying considerable pressure, got permission to allow the AEC to make some funds available to get the flight program under way.

The *Agena* vehicle and the Flight System-4 (FS-4) will be shipped to Vandenberg AFB this week for a flight test in April.

- **SNAP 50**—The 300-1,000-kw SNAP 50 program came in for considerable questioning by the JCAE, which appears increasingly irked at the fact that so many programs have been dropped before full tests were made because the user agency suddenly dropped its requirement. The committee's attitude may force a major decision on SNAP 50 this year.

SNAP 50, which was described as "withering on the vine," suffered a Budget Bureau slash of $6.7 million this year. The operating budget of $22 million has been "rescoped," AEC witnesses said.

Rep. Craig Hosmer (R-Calif.) questioned whether the program shouldn't be cut off now if it is going to follow the same pattern as some of the others. Although the Air Force was described as very much in favor of SNAP 50, Rep. Thomas G. Morris (D-N. Mex.), suggested that the Air Force's interest should be judged on the basis of how much money it is willing to put into the program. The Air Force so far has committed no funds. ■

AEC BUDGET BREAKDOWNS

(in millions of dollars)

RADIOISOTOPE POWER SYSTEMS OPERATING COSTS

	FY'64	FY'65	FY'66
Surveyor (SNAP 11)	0.3	0.4	0.5
Pu238 space generator	0.6	2.0	2.4
Sr 90 space generator	1.3	1.1	2.9
Advanced terrestrial generator	0.2	1.4	2.3
Milliwatt generator development	0.8	0.4	0.5
General research & development	0.8	1.4	1.9
Completed projects in FY 1965	1.4	0.3	0
TOTAL RADIOISOTOPE POWER SYSTEMS	5.4	7.0	10.5

ADVANCED SPACE POWER SYSTEMS

Lithium-cooled reactor experiment	2.5	0	0
Snap 50 experimental reactor	20.0	14.0	15.0
Snap 50 power conversion system	2.9	5.2	6.5
Component integration studies	0	0.5	0.5
TOTAL ADVANCED SPACE POWER SYSTEMS	25.4	19.7	22.0

SNAP SYSTEM IMPROVEMENTS PROGRAM

Reactor improvement	2.4	1.5	2.8
Improved thermoelectrics	1.2	2.5	2.5
Mercury Rankine cycle development	6.0	7.0	8.2
General research and development	0.9	1.5	2.0
TOTAL SNAPSI	10.5	12.5	15.5

NAA Easily Repeats as Top Contractor

Total spending jumps 42% to $4.594 billion; McDonnell and other Apollo contractors are high on list; competitive procurement rises

NORTH AMERICAN Aviation, Inc., in Fiscal Year 1964 again led the list of NASA prime contractors—receiving some 28% of the agency's total procurement of $4.594 billion.

The overall spending level was some 42% higher than the Fiscal Year '63 level of $3.2 billion. *(See list on p. 21)*

North American—prime contractor for the *Apollo* spacecraft Command and Service modules as well as some of the engine and booster stages in that program—was followed by the prime contractor for project *Gemini,* McDonnell Aircraft Corp., and other prime *Apollo* contractors, such as Douglas Aircraft Co., Boeing Co., Grumman Aircraft Engineering Corp., General Dynamics Corp., General Electric Co., Aerojet-General Corp., and Chrysler Corp.

The agency, in its annual procurement report, said that approximately 77% of the net dollar value of its contracts were placed directly with business firms, 3% with educational and other nonprofit institutions, 5% with the Jet Propulsion Laboratory and 15% with other government agencies.

In addition, it said that 78% of the procurement handled by JPL was awarded to business firms, as was 90% of the NASA procurement handled by other government agencies.

Competitive procurement in FY '64 was up slightly, 60% of total awards, compared with 58% in FY '63.

• **Breakdown**—In terms of types of contracts, NASA said that some 79% of the awards to business were placed under cost-plus-fixed-fee contracts. In line with the agency's policy of including incentive provisions in its contracts when possible, 8% of the total awards to business involved incentive contracts. Eleven per cent of the awards were placed under firm fixed-price contracts and the remaining 2% consisted of other types of fixed price and cost reimbursement contracts.

Small business's share of the total awards to business was 7%, or $240 million. These small firms also received $487 million in subcontracts from 43 large business firms serving as prime contractors in various programs. The total of $781 million for small business represents 21% of the total procurement of NASA and JPL. ■

Titan III-X To Fly in Summer of 1966

FIRST LAUNCH of the *Titan III-X* —newest entry in the U.S. stable of launch vehicles—is expected to take place in the summer of 1966. Approval for development of the booster, given in December by Deputy Secretary of Defense Cyrus Vance, was disclosed last week. First buy of the *Titan III-X* will total 24 vehicles.

Titan III-X will consist of the first two stages of the *Titan III-A* and an *Agena* upper stage. Two other options, not now considered real possibilities, are to substitute the *Transtage* for the *Agena* or to use *Centaur* as an upper stage for NASA missions.

The Air Force has submitted a program change proposal to DOD asking reprogramming authority for 1965 funds. If this PCP is accepted, work on the *Titan III-X* is expected to begin almost immediately. *Titan III-X* is carried as a separate line item in the 1966 budget.

Contractor structure for the new launch vehicle will be the same as that for the *Titan III.* Martin Co.'s Denver Div. will furnish the first two stages and serve as systems integration contractor, while Aerojet-General will furnish the engines for both stages. Lockheed Missiles and Space Co. will provide the *Agena.* Contracts with these companies are still being negotiated.

Launches of the *Titan III-X* will take place from a modified *Atlas-Agena* pad at the Western Test Range. There are no plans to launch the vehicle from the Eastern Test Range, but should a requirement for such launches arise, from either military needs or NASA missions, an *Atlas-Agena* pad at ETR would be modified to take the new booster. AF officials feel that this would be more economical than modifying the *Titan III* complexes for the shorter, lighter *Titan III-X* with its different requirements for handling and checking the *Agena* upper stage.

• **Modifications**—Major changes in in the *Titan III-X* as compared with *Titan III-A* include lightening the vehicle for more payload, removing the malfunction detection system and replacing the inertial guidance with a radio guidance system from Bell Telephone Laboratories already in use on other space boosters. These changes allow *Titan III-X* to place 1,300-1,400 more pounds of payload into a low polar orbit than can the *Atlas-Agena.* Weight is also saved by eliminating the batteries that power the guidance system and telemetry packages.

With the *Titan III-X*, in addition to the *Centaur* as a possible substitute, solid strap-ons could be used to boost the payload capability.

With the backlog of experience available with the *Titan III-A* test program, the *Agena* operational launches and the engines, the first launch will be a demonstration of the vehicle's readiness. From that point on, the booster is to be available for operational requirements. At the moment, the *Titan III-X* has only one payload—a highly classified satellite which requires the heavy lift capability of the vehicle into a low Earth-polar orbit.

Although NASA approval for development of the vehicle was obtained in December, space agency officials disclaim any plans to use the vehicle as a booster. The AF plans to keep the *Titan III-X/Centaur* option open, however. ■

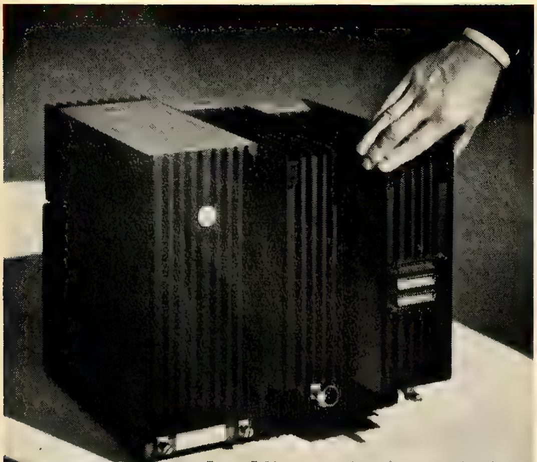
NASA LIST OF FY 1964 TOP 100 PRIME CONTRACTORS

	CONTRACTOR	SMALL BUSINESS	RANK IN FISCAL YEAR 1963	NET VALUE OF AWARDS	
				THOUSANDS OF DOLLARS	PERCENT OF TOTAL AWARDS TO BUSINESS
	TOTAL AWARDS TO BUSINESS			$3,521,095	100.00
1	North American Aviation, Inc.		1	917,244	26.05
2	McDonnell Aircraft Corp.		2	267,623	7.60
3	Douglas Aircraft Co., Inc.		4	250,306	7.11
4	Boeing Company		6	197,067	5.60
5	Grumman Aircraft Engineering Corp.		10	156,393	4.44
6	General Dynamics Corp.		5	148,200	4.21
7	General Electric Co.		8	143,562	4.08
8	Aerojet-General Corp.		3	135,776	3.86
9	Chrysler Corp.		7	99,414	2.82
10	International Business Machines Corp.		12	85,627	2.43
11	Radio Corporation of America		11	49,815	1.42
12	Bendix Corp., The		13	41,886	1.19
13	General Motors Corp.		24	41,886	1.19
14	Brown Engineering Company, Inc.		16	41,566	1.18
15	Lockheed Aircraft Corp.		17	39,019	1.11
16	Thompson Ramo Wooldridge, Inc.			38,995	1.11
17	United Aircraft Corp.		9	36,729	1.04
18	Philco Corp.		21	35,690	1.01
19	Raytheon Company		28	23,422	.67
20	Ling-Temco-Vought, Inc.		15	21,545	.61
21	Union Carbide Corp.		22	20,100	.57
22	Hayes International Corp.		20	18,715	.53
23	Blount Brothers Construction Co.			17,005	.48
24	Control Data Corp.		61	16,940	.48
25	Hughes Aircraft Co.		18	14,907	.42
26	Kollsman Instrument Corp.		34	13,584	.39
27	Mason-Rust		19	11,916	.34
28	Sperry Rand Corp.		47	11,797	.34
29	Ingalls Iron Works Co.			11,385	.32
30	Radiation, Inc.		35	10,797	.31
31	Fairchild Stratos Corp.		32	10,412	.30
32	Federal-Mogul-Bower Bearings, Inc.		37	10,337	.29
33	Air Products & Chemicals, Inc.		38	10,020	.28
34	Ernst/Smith Joint Venture			9,847	.28
35	Republic Aviation Corp.		25	9,286	.26
36	Northrop Corp.		68	9,187	.26
37	Bellcomm, Inc.		31	8,670	.25
38	Martin Marietta Corp.		27	8,452	.24
39	Documentation, Inc.	X	45	7,312	.21
40	Honeywell, Inc.		48	7,100	.20
41	Jones, J. A., Construction Co.			6,641	.19
42	Genisco Technology Corp.	X		6,576	.19
43	Ball Brothers Research Corp.		59	5,976	.17
44	Catalytic Construction Co.		33	5,931	.17
45	Westinghouse Electric Corp		39	5,900	.17
46	Spaco, Inc.	X	46	5,708	.16
47	Electro-Mechanical Research, Inc.		30	5,433	.15
48	Ampex Corp.		40	5,200	.15
49	Bell Aerospace Corp.		49	5,132	.15
50	Sullivan, Long & Hagerty		44	4,950	.14
	TOTAL AWARDS TO BUSINESS				
51	Collins Radio Co.		36	4,939	.14
52	Avco Corp.		41	4,898	.14
53	Scientific Data Systems	X	75	4,877	.14
54	Bechtel Corp.		92	4,737	.13
55	Pearce & Gresham Co.	X	58	4,536	.13
56	American Telephone & Telegraph Co.		56	4,499	.13
57	Garrett Corp.		53	4,256	.12
58	Consolidated Electrodynamics Corp.		72	3,978	.11
59	Wyle Laboratories		74	3,771	.11
60	Venneri, Arthur Co.			3,521	.10
61	Hercules Powder Co.			3,479	.10
62	Chicago Bridge & Iron Co.			3,205	.09
63	Electronic Associates, Inc.		67	3,205	.09
64	Space-General Corp.		82	3,184	.09
65	Basic Construction Co.			3,176	.09
66	American Machine & Foundry Co.		76	2,963	.08
67	Graham, Wm. J. & Son	X		2,957	.08
68	Huber, Hunt & Nichols			2,851	.08
69	Thiokol Chemical Corp.		42	2,792	.08
70	Doyle & Russell, Inc.		63	2,628	.07
71	International Telephone & Telegraph Corp.		89	2,601	.07
72	Vitro Corp. of America		65	2,496	.07
73	Lear Siegler, Inc.		23	2,483	.07
74	Management Services, Inc.	X	80	2,444	.07
75	Data Control Systems, Inc.	X		2,379	.07
76	Motorola, Inc.		50	2,310	.07
77	Beckman Instruments, Inc.			2,304	.07
78	Geophysics Corp. of America	X	100	2,242	.06
79	Gulton Industries, Inc.		97	2,230	.06
80	Blaw-Knox Co.			2,043	.06
81	Consolidated Systems Corp.		78	1,953	.06
82	Perkin-Elmer Corp.			1,942	.06
83	Whittaker Corp.		43	1,887	.05
84	Electro Optical Systems, Inc.		84	1,808	.05
85	Aluminum Co. of America			1,766	.05
86	Goodyear Aerospace Corp.			1,648	.05
87	Space Craft, Inc.	X	73	1,589	.05
88	American Science & Engineering, Inc.	X		1,576	.04
89	Systems Engineering Labs, Inc.	X		1,575	.04
90	Memorex Corp.	X		1,556	.04
91	Zia Company, The			1,527	.04
92	Textron Electronics, Inc.		85	1,516	.04
93	Xerox Corp.			1,457	.04
94	Cleveland Electric Illuminating			1,450	.04
95	Canoga Electronics Corp.	X	71	1,412	.04
96	Associated Builders Corp.	X		1,408	.04
97	Radiation Service Co.			1,396	.04
98	Schjeldahl, G. T. Co.	X		1,395	.04
99	Hewlett-Packard Co.			1,377	.04
100	American Optical Co.			1,371	.04
	Other			324,521	9.22

INTEGRATED CIRCUITS

+ MODULARITY

= NEW BURROUGHS D 84 COMPUTER



Basic D 84 occupies less than 1½ cubic feet, weighs only 100 pounds, requires only 110 watts.

Burroughs—

Meet a truly unique general purpose military computer, the Burroughs D 84.

Monolithic integrated circuits make it small, light, reliable and fit for the roughest ground, naval or airborne military environment.

Modular design allows it to exactly fit your application--and to expand as your requirements grow--without reprogramming.

Get the new D 84 technical brochure. Write or call Burroughs Corporation, Defense & Space Group, Paoli, Pa. Phone 215 NI 4-4700, Ext. 237.

Burroughs Corporation

Circle No. 18 on Subscriber Service Card

Technical Countdown

ADVANCED MATERIALS

Smoke Suggested as Radiation Attenuator

DOD may award a contract this year for investigation of smoke-producing devices as a way of attenuating the radiation and some blast effects of a nuclear explosion. Smoke generators mounted on utility poles throughout a community could be triggered to produce large quantities of smoke very quickly, researchers claim. Investigations have shown that smoke could attenuate certain blast emanations to an appreciable degree and "significantly" reduce hazardous effects.

ASTRONAUTICS

IR Balloon Telescopes, to Look at Venus, Mars

Now that its balloon-borne infrared telescope has shown that Venus cloud cover is made up of ice crystals, the Balloon Astronomy Group at Johns Hopkins University is anxious to use similar techniques to probe the planet's surface. Professor John Strong, head of the Group, believes that the surface temperature of Venus has yet to be measured. (Telemetry from *Mariner II* indicated clouds of condensed hydrocarbons held in oily suspension, no measurable water vapor, and a surface temperature of 800°F.) The next balloon flight by Strong's group will take place in March, to try to measure water vapor on Mars and, like many other experiments at the same time, to try for a reading of surface pressure on the red planet.

Meteors Formed Lunar Surface?

The upper layer of the lunar surface, to a thickness of about a decimeter, is porous and impregnated with meteoric materials. It has up to twice the electrical conductivity of the underlying layer. These are the conclusions of several Soviet radiophysicists led by Professor V. S. Troitskiy. On this basis, "the formation of the upper lunar covering was mainly the result of meteor bombardment and falling meteor dust," the Gor'kiy scientists feel.

X-15 May Measure Solar Constant

Use of the *X-15* to measure the spectrum and energy of incoming solar radiation is under consideration by JPL. The measurements will probably be made by precision filter and total radiometers. Program is of considerable importance to JPL as current uncertainty of up to 5% in the solar constant handicaps spacecraft design, particularly for *Surveyor* and *Voyager*. About six flights above the atmosphere would be involved with a program cost of about $1 million. Successful spectral measurements of high accuracy could be followed by extended measurements aboard a satellite.

Satellites to Measure Space Environment

Space-General Corp. is fabricating four low cost utility satellites, capable of a variety of experiments, under a $1.35 million contract for Air Force Office of Aerospace Research. Basic design, a right octagonal cylinder 30 in. high and 30 in. across overall, permits interchanging of experiments and eliminates constraints imposed on experiments by modular all-purpose spacecraft. Weight will vary from 130-160 lbs. Three will be launched from the Air Force Western Test Range and the other from Wallops Island, Va., atop *Scout* rockets. Experimenters will study the space environment, cosmic radiation, and personnel hazards associated with space radiation.

Obsolescent ICBM's Get Space Roles

Future space uses for *Titan I* are under study. *Atlas E* and *F* ICBM's, outdated as weapons, have already been assigned new roles in missile and space research, development, testing and training, Air Force reports, adding that "many millions of dollars worth of spare parts, ground support, electronic and communications equipment will be salvaged" from the outmoded ICBM force for use by DOD and other agencies.

SPACE MEDICINE

Prototype O_2 Recovery Unit Tested

A prototype ion-exchange membrane water electrolysis oxygen recovery unit for spaceflight has been developed and tested by General Electric's Missiles and Space Division. The unit was designed for NASA to support a four-man crew for periods up to one year with a 90-day resupply interval. The unit, which weighs approximately 100 lbs. and uses 945 watts power, produces 8 lbs. oxygen and 1 lb. of hydrogen each day. It employs ion-exchange membrane pocket type electrolysis cells to electrolyze water.

Animal Decompression Studies Continue

Research into effects of decompression on primates continues to bear out the new theory that animals can survive a longer exposure to vacuum than previously thought, and may be able to make a total recovery from any disability associated with it. A joint NASA/Air Force-supported study at San Diego State College concluded that if life is spared restoration of function to predecompression baselines is highly probable. Trained squirrel monkeys were decompressed to less than 2 mm Hg abs for periods up to 90 seconds, and then given psychomotor tasks one week and two months later.

Trampoline Aids Weightlessness Study

Boeing Co. recently completed a 15-day test to study the efficiency of a trampoline device as a cardiovascular conditioner for weightlessness effects. Four subjects were confined in bed except for brief periods of passive exercise on the trampoline device, to which they were moved on stretchers. The bed-like platform moves back and forth along its longitudinal axis, subjecting the prostrate man to accelerations alternately from the foot and head. Preliminary data was reported as favorable for the 1½-g exercises.

Opossums Proposed for Orbital Tests

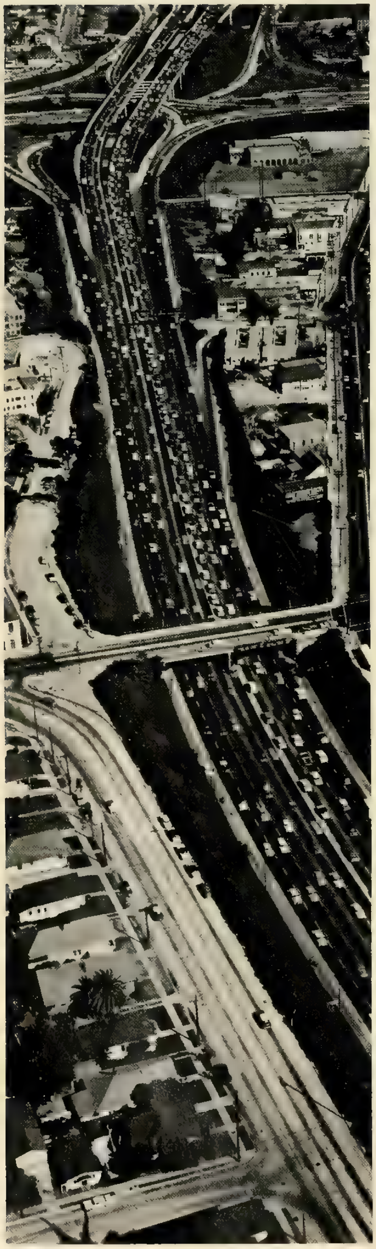
Radio Corp. of America and The Marquardt Corp. are proposing a study to the Air Force in which opossum fetuses could be used as a biological indicator for possible deleterious effects of weightlessness. Study would involve various aspects of design of the experiment for a biosatellite of the RCA SERT-type spacecraft, to be boosted by a *Scout* booster. Twenty-four opossums would be orbited from 60-90 days, to study the development of body systems in weightlessness, according to the unsolicited proposal.

SPECIAL REPORT:

Industry Studies California Problems

Four firms already are enlisted to help solve state difficulties in non-aerospace areas; a potential showplace for systems approach

by Willard E. Wilks



TRANSPORTATION headaches, typified in view of four-level expressway complex in Los Angeles, are being attacked in study by North American Aviation, Inc.

SACRAMENTO, CALIF.—With high-level Washington blessing, the California state government has undertaken an experiment designed to show that the aerospace industry is uniquely qualified to help solve some pressing and large-scale civilian problems.

The program is the spearhead for a major state campaign to get substantial Federal funds committed to research and development activities outside the defense-space area while turning California into a showcase for such effort.

The experiment involves four $100,000 state-financed study contracts, to be completed in six months, under which aerospace firms are applying the systems approach to solution of state problems.

Though the program is idealistic and has excited the imaginations of many who envision startling and futuristic products emerging from the space laboratories, the state's motivation is hard-headed: The industry provides a major portion of California's employment and tax base. The new move is an attempt to strengthen the state's economy by helping its industry develop a broader base.

● **Reasons why**—The California economic conversion plan is based on a number of facts, assumptions and hopes. Gov. Edmund G. Brown and other state officials made these points in a series of interviews with MISSILES AND ROCKETS:

—Last fall, after Secretary of Defense Robert S. McNamara wrote Brown a letter assuring him that defense spending would "remain at about its present level for the next several years," state officials decided this wasn't good enough to maintain the California economy. "We need a constant increase to keep up with our steadily growing population," one spokesman said. "If the state economy stays level, we're in trouble."

—A key assumption is that while defense spending may level off, overall Federal spending will not decline, and a leveling off will be accompanied by allocation of Federal funds to other public needs. State officials see a number of encouraging signs pointing in this direction.

—The state's 6.5% unemployment figure is higher than the national average. Some 25% of its employment is in the aerospace industry, and officials estimate that another 12% is employed in support of it. A state repercussions analysis shows that due to a multiplier effect, a reduction of $1 in production in the defense industry means a $2.57 reduction in total wages and salaries.

—California has an inventory of major unmet public needs which cannot be met by existing tax resources.

—The aerospace industry is not now capable of making any major changes in its customers from the public to the private sector of the economy. But it is capable in its present form of solving problems unrelated to aerospace by use of the systems approach.

This last assumption is being put to test by the study contracts, says Jack Halpin, until recently chief deputy director of state finance and now head of Brown's conversion program. "This assumption is only being used tentatively for policy decisions," he asserts, "and one of the goals is to see if it is correct."

The assumption as to changing customers "is not altogether flattering to the industry," Halpin says, "but the kinds of problems (industry firms) have been solving are so large in scale that it is difficult to think of a private demand which could approach that scale. Also, their organizational structure does not have any marketing ingredients to amount to anything. This doesn't mean they couldn't acquire them."

● **Real contributions**—Gov. Brown emphasizes that the contract effort is in no way a "make-work or WPA program."

He says the contracts deal with "hard" state problems to which the advanced technology and management methods developed in aerospace activities appear readily applicable. Further, they are the same as, or similar to, large-scale problems confronting the Federal government and other states, and thus may provide the possibility of generating new business on a national scale.

The contracts include studies into the design of a statewide waste management system (Aerojet-General); a system to provide for the detection, rehabilitation and institutionalization of the juvenile delinquent and criminal population (Space-General); an information system using advanced techniques to provide timely advance planning for public needs (Lockheed Missiles & Space Co.), and a complete, integrated transportation system (North American Aviation). All are to anticipate the state's development over the next 30-50 years.

Brown is counting on final reports from the six-month studies to provide the basis for a major presentation in Washington. Federal funds will be sought in part on the basis that such new system designs could be useful in places other than California.

California officials, who have kept Washington closely informed on the plan from the beginning, see signs that Federal thinking is going in the direction of funding more non-defense R&D and that agencies other than DOD and NASA are becoming more interested in new ways to use industry abilities.

Washington has been studying the aerospace diversification problem, and attention is called to such moves as that of then Sen. Hubert Humphrey (D-Minn.) in introducing a bill discussing application of the systems approach to major national problems.

"The tax situation also appears to be developing favorably, with the President's economic advisors discussing the sharing of surplus tax monies with the states," a state official pointed out.

● **Alone if necessary**—In case they have no immediate success in Washington, however, California officials are considering ways and means of proceeding beyond the study stage in the areas under contract, both to put the industry to work within the state and to create a showcase for customers outside the state.

"We are not going to wait for Federal participation," Halpin said. "All of the study contracts call for contractor investigation of financing as well as engineering devices."

The particular problems involved in the studies were chosen in part because the state could act on their solutions sooner than it could in other areas. "For instance, the information system—there seems to be no reason why we couldn't buy one now," Halpin said.

Officials talk of money for the program as coming from a variety of sources, but admit it is difficult to pinpoint anything at this stage.

● **Hazy stage**—"It's fuzzy," Gov. Brown says. "It's frankly an experiment. We're just trying to plant a seed. But it's not a stop-gap. It's a real effort to bring these 'organized brains' into our everyday problems. We feel that it would be ridiculous not to."

"It has to be fuzzy at this point," says Halpin. "We found the state couldn't expect to do more than show the way. Obviously, we don't have the fiscal resources to go into major R&D programs.

"We envision a combination of resources that would include the state's traditional funding of those problem areas it has always had to fund. We've always had responsibility to provide some elements of the transportation system, and the same is true in the housing, feeding and rehabilitation of the mentally ill and criminal elements.

"We also expect to make demands for large Federal commitments to R&D, either through the state, as contractor, or directly to its existing structure—such as public roads and health, education and welfare. Another element is the private sector. We foresee the possibility of a more sophisticated fiscal mix."

Halpin says "we may be able to apply the traditional funds in different ways. It also could be that savings will result from more efficient systems, and that some systems could be made to pay for themselves. The California water plan, for example, is financed entire out of users' fees."

In the areas under investigation, the state government alone spends more than $100 million a year in corrections, with local governments spending another $350 million annually on the criminal problem, including police and courts; the state government budgets $700 million a year for highways alone, not including such local government projects as the $900-million San Francisco rapid transit sytem; some $15 million a year is spent by the state government on electronic data processing alone, and in waste management the state government spends about $2 million a year for regulation, surveillance, monitoring and data gathering, while the capital investment in facilities and equipment by local government and industry adds up to some $3 billion.

Officials believe the aerospace industry studies may make it possible to finance improvements out of existing commitments.

Two state executives concerned with waste management and transportation declare "a lot of economy" is expected to result from long-range planning of facilities on a broader geographical basis than is done now.

"Given the additional population load that is certain to be placed on the waste management system in the next 10 to 20 years, proceeding on this study basis is a plan for victory rather than a plan for certain defeat, which is what we face under the present system," one said.

Likewise, officials report, early detection of juvenile delinquents who could be rehabilitated without incarceration would save the $15,000-$18,000 it costs to provide a bed in an institution, and combining the state's various information gathering and processing activities into a single system could not only save money but lead to bene-

SOAP SUDS POUR into stretch of Sacramento River. Aerojet-General is performing study of statewide waste management.

MISSILES AND ROCKET

HIRD ANNUAL DOD ISSUE, March 29, 1965

advanced technology and the DOD

Advanced Technology is the key to growth in the future. The March 29 issue of MISSILES AND ROCKETS will concentrate on the applications of advanced technology to tactical warfare. It will encompass all phases of advanced technology for which the Defense and Space Industries have a unique capability and for which the DOD has unique requirements.

This issue will cover:

Advanced Technology: materials, electronics, power sources and basic research

Systems: combat support, air defense, command and control, mobility, and counter-insurgency

Plus these valuable guides:

Complete organization charts, procurement contacts and all defense level organizations involved in tactical warfare including DDR&E and ARPA.

Your advertising will have greater impact, greater importance and greater readership among the men making the important buying decisions in the military and industry.

PLAN NOW TO CAPITALIZE ON THIS UNIQUE EDITORIAL ATMOSPHERE.

M/R

Advertising Closes: March 15, 1965

Issue Date: March 29, 1965

fits in other areas, including more accurate decision-making.

State officials directly concerned with the problems under study are as enthusiastic about the program as the governor himself, while being wary of possible pitfalls. "One thing we'll want to watch," said one, "is that the aerospace companies are used to dealing with technical and scientific kinds of data. The state is working with the human element, and we will have to see that this is preserved."

• **Line forms**—Since industry leaders serving on the governor's aerospace panel helped design the California experiment, response has been enthusiastic. Fifty-one proposals were submitted on the four RFP's, and some companies responded on several. A division of one large firm, noting completion of one major R&D program and recent cancellation of another, said in its proposal that if it was "to continue as a major economic factor in California," it would have to find business outside the defense market.

• **Transportation**—Because of the nature of the problem, the transportation study proposals were expected to produce the most eye-catching innovations and in this regard they were not disappointing.

In its winning transportation study proposal, North American Aviation stated: "Rockets taking Californians to New York in minutes, tube trains with San Francisco-to-Los Angeles times similar to today's jets, individual air-cars from home to office, hands-off control of all vehicles on freeways, automated pipeline movement of produce from farm to home in hours, continuous flow of mail from drop box to destination . . . all and more are feasible within California in the next 50 years."

NAA's proposal made it clear, however, that careful and completely integrated planning is needed lest "a catastrophic jumble" result. Praised by state officials for its breadth and sophistication, the proposal won on the basis of the stated need for a thorough analysis of all conceivable factors affecting the transportation problem. A state spokesman said the whole approach taken "reflects the McNamara concept of systems design, as contrasted with traditional military design efforts, emphasizing the development of cost and effectiveness criteria in evaluating the systems as well as alternate systems and necessary models."

In its proposal, Northrop Corp. suggested that railroad equipment might be made lighter and more reliable through aircraft construction principles and new materials. As examples of what might be considered, Northrop also suggested that with atomic power plants and other factors reducing cost of large quantities of electricity, the question of electrification vs. diesel, gas turbines or some new form of energy may again come to the fore.

Unlike the other contracts, the one on transportation is for design and development of specifications for a study.

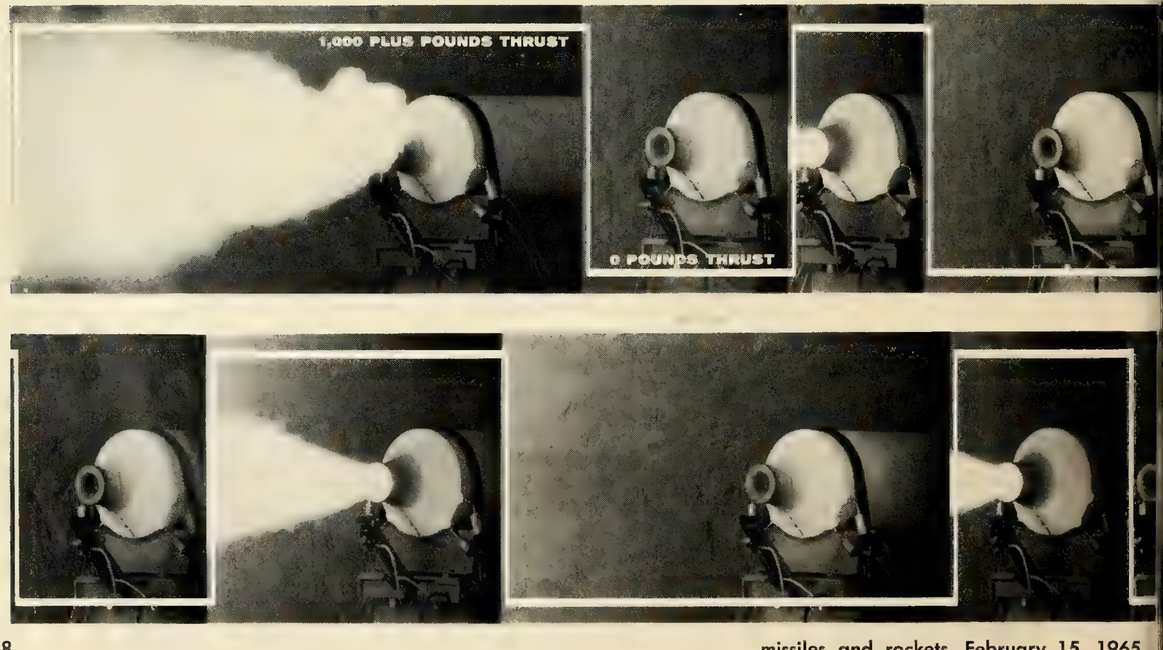
• **Waste management**—In its winning proposal for the waste management system study, Aerojet-General said a plan for evolution to a modernized system "must eventually encompass major changes in approach. A series of small modifications of present facilities will not suffice."

The company thought gains may be achieved by integrating the treatment of both garbage and trash. Attention also was called to such problems as an inefficient tidal exchange that does not carry away sewage from numerous small treatment plants in San Francisco bay.

Aerojet said an important part of the study will be to evaluate the R&D impact on California industries. "The extent to which various programs will bring new technical skills into the state and cause diversification of existing industries should be estimated. The effects of the resulting technological fallout—e.g., the development of superior proc-

---

Now...fire and re-fire...on command



esses for treating large volumes of water as an attraction for additional water-dependent industries—will be considered."

Another R&D fallout, Aerojet reported, would be the upgrading of the state's technological skills. "The types of experienced people these programs will attract and develop will give California industries the ability to acquire new business outside the state. Attempts will be made to identify some of these areas. Of equal significance will be identification of areas in which California industry is presently incapable of responding."

Among the firms suggesting innovations in waste management was United Technology Center, which proposed waste treatment with newly developed chemical compounds to promote the growth of bacteria to process waste and thus reduce the degree of processing at the main treatment plants.

● **Information systems**—In its winning proposal for the information system study, Lockheed Missiles & Space Co. said requirements for an improved system include comparative data on occupational trends and prospects, automatic surveillance of the incidence of diseases and various handicaps, correlation of employment opportunities with educational requirements, and improved methods for keeping track of discharged mental patients, probationists and ex-convicts.

● **Know-how available**—In all of the proposals, companies cited as principal qualifications their work on large, complex weapon systems and on the space program. This background was emphasized in the experience of the teams assigned to the study task.

In a significant number of cases, firms were able to cite background which related more specifically to the problems involved, indicating the considerable diversification capability within the industry. Litton, for example, listed work in behavioral technology and education, public works, transportation and traffic control, energy and natural resources utilization, and pollution control.

Large rocket firms noted capability in waste management and control of toxic materials at rocket test sites. North American Aviation pointed to its industrial photosynthesis program and operation of a large desalinization pilot plant; United Technology Center referred to its operation of a large-scale chemical plant; Garrett and others mentioned experience in space life support and waste systems.

A number of companies spoke of their considerable experience in information-data handling, and airplane manufacturers called attention to their significant experience with transportation problems, as well as factory assembly lines.

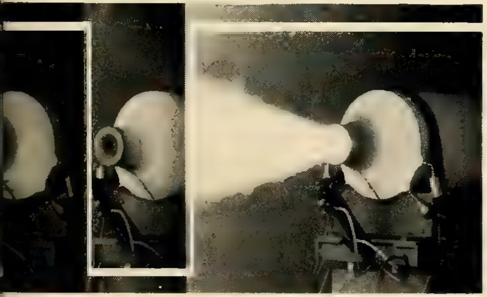
● **"Only beginning"**—Although responding enthusiastically to the state's program, many aerospace spokesmen say that even at best they do not expect it to produce much income—or even to prevent possible further belt-tightening. There is general agreement, however, that it is positive action that could pay off over the long term.

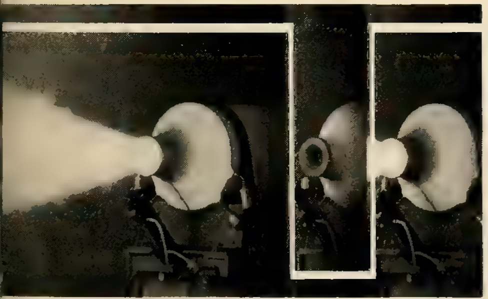
Reaction has ranged from comment that "you aren't going to get a *Titan* or *Minuteman* program out of it," to such observations as that of Litton Industries in its proposal on the waste management system study: "A number of the waste management programs contemplated in California are comparable in scope and total dollar value to many of the important weapon systems developments undertaken by Department of Defense."

Other industry observers point out that while aerospace firms may be capable of designing or managing a better waste management system, they are not likely to win contracts for ditch digging and soil pipe production.

"Real production hardware possibilities appear pretty vague," a spokes-

om Lockheed Propulsion: This 40 pulse
lid rocket motor. Fires propellant wafers
conds apart... or days apart.





PROBLEM: Develop a lightweight solid rocket motor which can be fired, shut down, then re-fired, in sequences of seconds, hours or days. This was the assignment of the Air Force Systems Command to Lockheed Propulsion Company.

LPC's solution is a pulse motor which uses solid propellant wafers. Each wafer develops over 1,000 pounds thrust, is separated by a thermal barrier. On manual, radio, or pre-programmed command, the wafers can be fired singly or in rapid bursts. Time between wafer firings can be as little as milliseconds—as much as days.

This latest LPC advance in solid motor thrust control, following company developments in other forms of energy and thrust vector control, opens the door for utilization of solid motors for a wide variety of air-launched or space-launched missions.

In other important projects, LPC has twice test-fired a massive 156-inch solid rocket motor which developed over 1,000,000 pounds of thrust, and simultaneously demonstrated new advances in thrust vector control for the Air Force. Now, a revolutionary emergency ballast expulsion system is being developed by LPC for the Navy. This system uses solid propellant gas generators to pressure-expel tons of sea water from the ballast tanks of nuclear submarines, at least ten times faster than present methods.

PROPULSION ENGINEERS: These wide-ranging, expanding programs offer excellent career opportunities to qualified engineers, extending from junior into management level positions in the fields of preliminary design, advanced design, and analytical engineering. We invite you to write: Professional Employment Manager, Department 5202, P.O. Box 111, Redlands, California. An equal opportunity employer.

LOCKHEED PROPULSION COMPANY
REDLANDS, CALIFORNIA • A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

man said. "But then this is only the beginning. If we can begin getting into these non-defense areas, perhaps things will develop."

Another observed that "our products are advanced technology, advanced systems, and some very expensive hardware. Ultimately, the big dollars are in production, hardware—and programs the size of *Minuteman* are a long time in coming. This state program is not a near-future payoff. It's a long-term thing, but this is not really unusual if you are talking about any transition in industry."

- **Down to Earth**—No one in Sacramento or elsewhere disagrees with this comment. The big aim of the study contract program is to show potential customers outside California, DOD and NASA what the industry can do when applied to "down to earth" problems.

Observers outside the industry tend to expect it to propose solutions that are too futuristic and therefore, from one standpoint or another, impractical. Industry spokesmen say this feeling is understandable, since, of necessity, the industry's stock in trade has been the ability to innovate, to seek the major advance.

Combatting this attitude is no great problem, but the fact that the industry is geared to utilizing technology and tools that are considerably ahead of those in many non-aerospace areas presents some major hurdles.

One engineer told what happened when his company recently entered a competition to design a new rapid transit car for a city:

"They said they had an open mind and wanted new ideas. We tried to break with convention, do it a completely new way, and suggested, among other things, that the car might not need wheels.

"We didn't win. The point is that designing a car that is merely streamlined is not for the aerospace industry. A new, lightweight car, using new light metals—that's what the industry can do. The established transit car manufacturers are not tooled up for this."

- **Tailoring needed**—Another industry spokesman said that while the industry could contribute the systems approach to solution of problems presented by the state, "it's a little vague to me how we're going to get wealthy on this. The basic facts of life seem to preclude it. In dealing with DOD, if you come up with a new gimmick that requires new training. DOD establishes new schools. Or if you need a new facility, you go out and procure it.

CALIFORNIA State Prison at San Quentin. Space-General Corp. has a study covering detection, rehabilitation and institutionalization of state's criminals.

"But when you get into civilian life, dealing with unions and with job skills, our solutions are going to have to be tailored to their ability to handle them. So the compatibility seems to come apart. In waste disposal, for instance, the existing sanitary department and skills are not adapted to handling the sophisticated solutions."

Others note that aerospace-type solutions will require legislative changes that are difficult to obtain, constituting a serious roadblock to such things as a large-scale integrated transportation system. Various social entities would be required to surrender certain authorities. Investigation of the legislative angles is part of the four study contracts.

- **Accommodations**—The California government is aware of these difficulties and is already at work trying to remove them through adoption of advanced techniques into the governmental structure itself. In thought and action, state officials are moving to give the state government an "advanced technology look" in various ways:

—In the works are plans for adoption of a "program budget" to permit new and more flexible ways of funding and procurement; a new economic model which will define the state's economy with a series of equations covering 57 sectors, to streamline the legislature and governmental procedures.

—There is discussion of having contractors handle more of the public works problem "because we have been criticized for not having enough innovations and attention to esthetics involved in public works."

—Advanced planning techniques are being sought.

—Development of ways to permit more competition between the state and private enterprise in certain public service areas has been discussed.

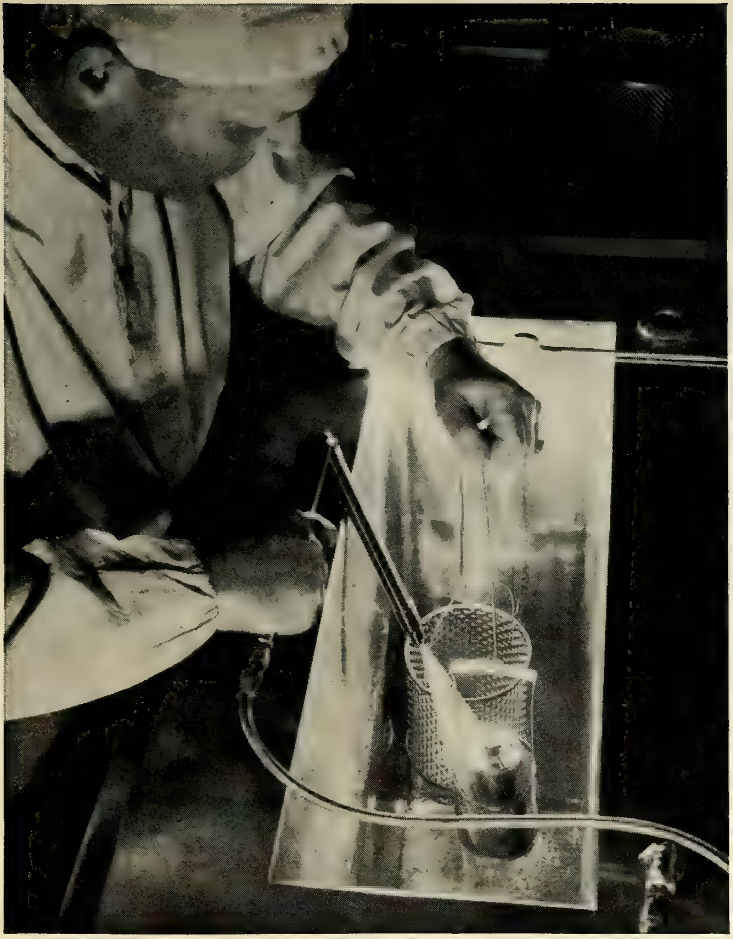
Meanwhile, despite the obstacles, aerospace firms are investigating more ventures into the civilian market.

A company that has been the No. 1 government contractor in recent years is considering going into the rapid-transit business itself—with gyro-stabilized cars that would be leased to the public. The system would avoid the big disadvantage of the conventional transit system by providing a vehicle, perhaps the size of a Volkswagen, that would travel both in a special channel and on city streets, permitting "door to door" rapid transit.

It is believed the system would be relatively inexpensive to build, the shallow channels for the wheels being placed along existing freeway rights-of-way, and would pay for itself. Traffic in the channels would be automatically spaced and controlled.

The company, which has set up a special team to investigate the concept, formerly displayed little interest in diversifying outside the DOD-NASA market.

Aerojet-General is preparing to go to the Department of Comerce with a proposal for a high-speed transit tube between Washington, D.C., and New York or Boston. A partial vacuum would be maintained in the tube to permit very high speeds. It is described as a unique approach "but a practical one—not a launch pad." ■



When cleaning is critical, Sperry uses FREON® Precision Cleaning Agent

Part of the gyroscope manufactured by Sperry* for the inertial guidance system of supersonic aircraft has to "float" in the damping fluid. The damping agent is a complex chemical polychlorotrifluoroethylene.

The cleaning of the floated portion is a critical operation for which Sperry relies on an ultrasonic vapor rinse of Du Pont's FREON Precision Cleaning Agent. The system was engineered and constructed by Branson Instruments, Inc., Stamford, Conn., an agent for "Freon" solvent cleaning systems. This is the type of complete service manufacturers have come to expect from representatives for Du Pont FREON solvents.

FREON is a *selective* solvent... it thoroughly removes all contaminants without affecting the materials of construction. Its low surface tension enables it to penetrate even the most minute crevices, and its high density permits it to float away particulate matter.

And FREON is so stable that by using a simple recovery unit, Sperry can reuse it. This, combined with increased production efficiency, results in cost savings.

If you would like more information on how *economical,* nonflammable, virtually nontoxic FREON fluorocarbon solvents can improve your cleaning operations, mail the coupon below.

*Sperry Gyroscope Company, a division of Sperry Rand Corp.

Du Pont Company
Room 2278, Wilmington, Del. 19898

Please send me information on FREON solvents. I am interested in cleaning ____
____

Name ____ Title ____

Company ____

Address ____

City ____ State ____ Zip ____
OFFER GOOD IN U.S.A. ONLY

FREON® SOLVENTS

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING ... *THROUGH CHEMISTRY*

Circle No. 6 on Subscriber Service Card

Breakthrough Foreseen in Early '70's

Bendix engineering official says urgency, economic incentive and radical new technique will bring system other than mass expulsion

A PROPULSION breakthrough around 1971 is highly probable—and the technical approach probably will be based on producing a force by some means other than mass expulsion.

Clyde R. Murtaugh, an engineering manager at Bendix Systems Division, told a combined meeting of the American Society of Mechanical Engineers and the Institute of Electric and Electronic Engineers in Detroit this week that the conditions for a technical breakthrough will exist by the early 1970's.

Although forecasting inventions is highly risky, and such events are supposedly unpredictable, Murtaugh says an analysis of the history of breakthroughs reveals the existence of reliable precursors.

- **Ingredients**—Murtaugh says these causes must exist simultaneously to produce a breakthrough:

—An urgent need—identified by a real, well-defined technological barrier standing firmly in the path of immediate progress.

—An economic incentive of sufficient magnitude to justify rapid development of the supporting technology—not previously applied to this barrier—in the face of established processes, facilities and product lines.

These have existed before every major technological breakthrough in history.

In addition, says Murtaugh, a breakthrough is characterized by the emergence of a new technique—one that differs radically from the technique leading to the barrier. The importance of this element, says the Bendix scientist, cannot be stressed too highly.

The last causative factor is that adequate supporting technology must be available. The merit of this consideration in forecasting the occurrence of a breakthrough is severely limited by an inability to predict which technology will be called upon to support the new development.

An example given by Murtaugh to support this point is that James Watt's inventions for the steam engine depended for their success on advancements in the metalworking trades. His 5-ft.-dia. pistons were only an inch out of round—an unprecedented degree of accuracy at the time.

- **The new barrier**—Murtaugh applied his analyzation of breakthrough forecasting to the propulsion technology as it now exists. Evidence of a barrier is established in the current space program.

After citing data, derived from many sources, covering the future of space exploration beyond the *Apollo* program and focusing on a manned Mars landing in the 1980 time period, Murtaugh defines the propulsion barrier as the requirement for an order-of-magnitude —or better—reduction in launch costs from Earth to a low Earth orbit (300 n. mi).

Murtaugh claims this is a real and well-defined barrier because alternative propulsion systems—recoverable stages, nuclear stages, etc.—offer cost reductions of only 50-75%. In most cases, these approaches raise more technical problems than they settle.

The urgency of the barrier is indicated by the fact that it is impeding progress beyond the present lunar goal. The economic incentive is there—the projected difference between supply and demand exceeds $2 billion per year after 1972.

Murtaugh says the prediction of a propulsion breakthrough is supported by the evidence that the freight-rate barrier is real and imminent—but the assumption of a steady increase in demand rather than a plateau after 1971 requires further examination.

The continuing increase hinges on making a manned trip to Mars before 1980. Two alternatives might affect this demand:

—Dilution of planetary exploration activities by increased interest in some related field such as oceanography.

—Substitution of a national objective in a different field—for example, education, medicine or food production.

- **Narrowing down**—The exact nature of the breakthrough is extremely difficult to predict, but one can eliminate certain areas. Since one of the most reliable features of a breakthrough is that it involves a radically different approach, the current principle of using mass acceleration to produce thrust can be eliminated.

Murtaugh leaves two techniques after his process of elimination: a self-contained source of "pure" force defined as requiring no exhaust of propellant mass, and the supplying of thrust from an Earth or lunar base.

Three "pure" forces are known—gravitational, electric and magnetic. Each has a place in Einstein's universal field theory and may be viewed as a type of anti-gravity.

A more specific characteristic, says Murtaugh, is that each depends on having a pair of objects, charges or poles. If the Earth constitutes one of the pair and the spacecraft the other, the effect would diminish rapidly as the range approached planetary mission distances.

But if the field could be concentrated and focused—as in recent laser work with light rays—the distance factor would be alleviated, says Murtaugh.

There are other areas which exhibit the environment most suited to breakthroughs. Murtaugh lists the following as possible areas.

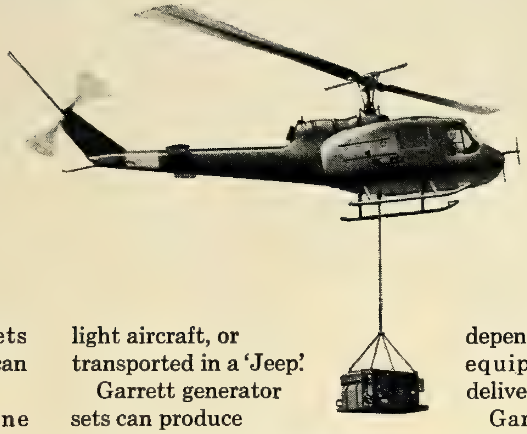
—Cost-complexity-reliability of aerospace equipment. The demands are such that extreme cost and long development schedules exist to the extent that the next generation of payloads should have been started before the present generation.

—System management. The ability to design advanced aerospace systems is rapidly outstripping our ability to manage these efforts. Some new means must be found for digesting the pertinent facts —or opinions—and formulating timely, accurate management decisions.

—Information transfer. The technological explosion is producing new information faster than it can be absorbed.

Murtaugh emphasizes that a key step is in establishing a well-defined statement of the problem—i.e., the barrier. Perhaps, he says, one of the existing difficulties is that the propulsion problem is usually stated in chemical or thermodynamic terms. ■

What is the big advantage Garrett-AiResearch gas turbine generator sets have over diesel and gasoline engines? Mobility.



Lightweight generator sets made by Garrett-AiResearch can be moved fast.

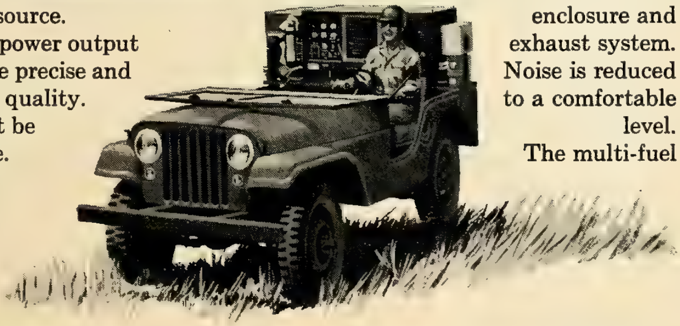
Heavy diesel and gasoline engines can't.

And *that* is one big reason why Garrett gas turbine generator sets are being specified more and more frequently in place of reciprocating engines.

Today, any modern weapons system – ground radar, missile support, or communications unit – must have the ability to move on a minute's notice.

That means it must be equipped with a lightweight, portable power source.

The power output must be precise and of high quality. It must be reliable.



Garrett gas turbine generator sets fill the bill on all counts.

For example, four men can easily carry a 20 kw or 30 kw generator set made by Garrett, or it can be airlifted by helicopter or light aircraft, or transported in a 'Jeep.'

Garrett generator sets can produce 50, 60 or 400-cycle electrical power or combination outputs ranging from 20 to 250 kilowatts.

Garrett sets are built tough – to withstand shock and rough handling in field operations.

Our sets operate reliably in any weather – with immediate starts from minus 65° to a plus 125°.

Starting, electrical loading, and shutdown functions are automatic.

Sound attenuation is an integral part of the enclosure and exhaust system. Noise is reduced to a comfortable level.

The multi-fuel capability of Garrett sets permits them to run on jet fuel, AV gas, diesel fuel, natural gas or commercial gasoline.

Because Garrett has built over 10,000 small gas turbines, proved dependability comes as standard equipment with every set we deliver.

Garrett-AiResearch generator sets are currently at work with many military units: The U.S. Air Force, U.S. Marine Corps, U.S. Navy, U.S. Army, NASA, as well as with foreign military groups.

For further information, write to J. A. Connell, AiResearch Manufacturing Division, 180 N. Aviation Boulevard, El Segundo, California.

Garrett
is **experience**

GARRETT

AiResearch Manufacturing Divisions
Los Angeles • Phoenix

Circle No. 7 on Subscriber Service Card

Test Stand Aids Polaris Mission

Kollmorgen facility permits accurate, repeatable calibration of celestial tracking periscopes to within 0.2 second of arc

by Charles D. LaFond

Northampton, Mass.—An optical test stand constructed for the Navy by the Kollmorgen Corporation for test and final alignment of Type 11A *Polaris* submarine navigational periscopes may well rank as one of the most stable facilities of its kind ever constructed.

The Navy's ultra-precise celestial tracking periscopes are built here at the principal Kollmorgen plant and then trucked to the big test facility at nearby Hadley, according to Herbert Torberg, Kollmorgen director of engineering.

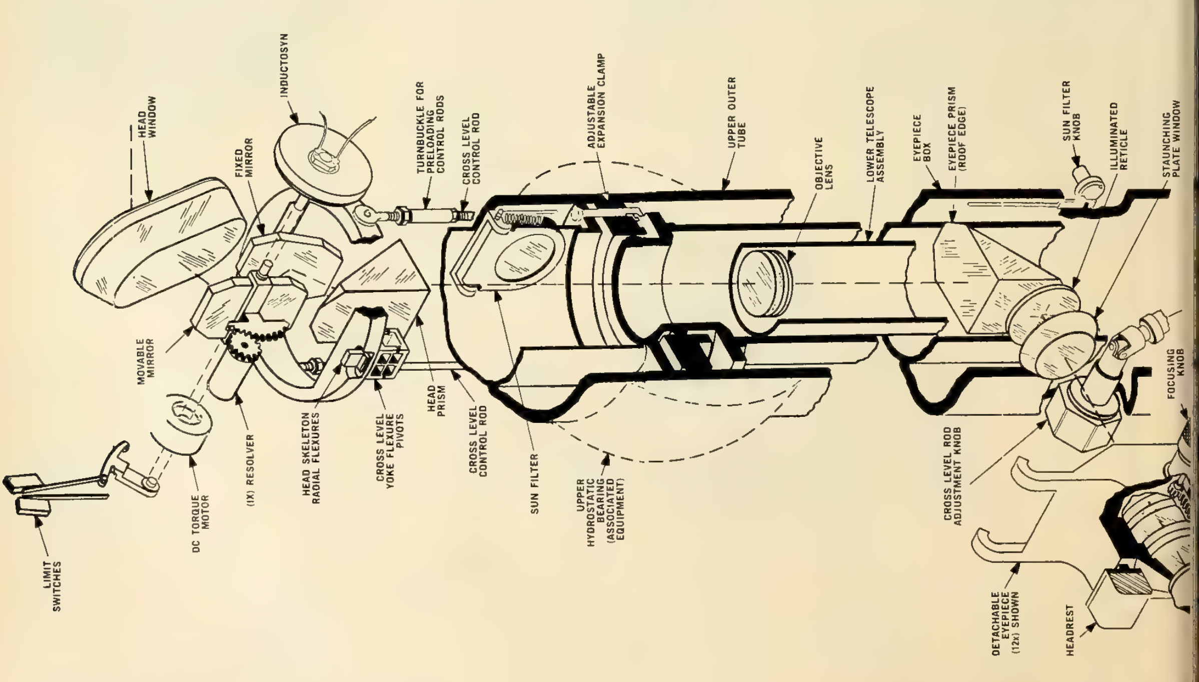
Twin 35-ton, 8-ft.-dia. silos rising 46 ft. above massive concrete isolated slabs permit repeatable calibrations of the big scopes to within 0.2 arc second over a two-month measurement period, Torberg disclosed. Periscopes under test and alignment are mounted vertically on the side of each silo. Measuring 44 ft. in total length, the Type 11A periscopes weigh about 2,400 lbs. each.

The silos, constructed on bedrock, are isolated from the building structure. The latter, along with a complex environmental control system, holds ambient temperature to within 1°F throughout each of five horizontal temperature zones from the floor to ceiling of the 55-ft. tower, said Torberg.

- **Type 11A periscope**—Representing a step advance over conventional periscope design, the Type 11A periscope is a two-axis, infinity collimated optical system. Computer controlled upon operator command, its celestial tracker is servo driven in train and elevation to acquire particular stars.

It serves as a deck reference; the differences between actual star sightings and computer predicted locations—based on the Ship's Inertial Navigation System (SINS) and other navigational aids—can be interpreted as position errors. The magnitude of the corrections in azimuth and elevation can then be reinserted into the computer for subsequent SINS update.

Thus, the accuracy of position determination using the Type 11A scope depends to a large extent on the accuracy of the original alignment or collimation. Continued accuracy of observations rests with system design and fabrication and the operational reliability of its mechanisms.


HEAD WINDOW
INDUCTOSYN
FIXED MIRROR
TURNBUCKLE FOR PRELOADING CONTROL RODS
CROSS LEVEL CONTROL ROD
ADJUSTABLE EXPANSION CLAMP
UPPER OUTER TUBE
OBJECTIVE LENS
LOWER TELESCOPE ASSEMBLY
EYEPIECE BOX
EYEPIECE PRISM (ROOF EDGE)
SUN FILTER KNOB
ILLUMINATED RETICLE
STAUNCHING PLATE WINDOW
MOVABLE MIRROR
FOCUSING KNOB
HEAD PRISM
CROSS LEVEL CONTROL ROD
(1X) RESOLVER
HEAD SKELETON RADIAL FLEXURES
CROSS LEVEL YOKE FLEXURE PIVOTS
SUN FILTER
UPPER HYDROSTATIC BEARING (ASSOCIATED EQUIPMENT)
CROSS LEVEL ROD ADJUSTMENT KNOB
DC TORQUE MOTOR
LIMIT SWITCHES
DETACHABLE EYEPIECE (12x) SHOWN
HEADREST

Final periscope alignment must be performed at the Kollmorgen Hadley facility. After installation and checkout in the submarine, there is no practical method to refer back to for checking the original alignment.

- **Opto-mechanical functions**—The Type 11A periscope consists basically of a head assembly containing the celestial tracking subsystem, an outer tube (hermetically sealed housing), an inner tube containing the telescope optics, the eyepiece assembly, and an intricate cross-level control rod and adjustment assembly for optical alignment compensation. The whole is supported by upper and lower hydrostatic bearing assemblies, when installed in a submarine.

- **Site selection**—To meet the unusually rigid alignment accuracy requirements in the manufacture of the Type 11A scopes, Kollmorgen engineers and consultants made an intensive study of the area around Northampton including data available from the U.S. Coast and Geodetic Survey office. The principal task was to find the best site suitable for the bedrock location of its alignment facility.

Previous studies had shown that the existing alignment towers, while suitable for conventional periscopes, experienced long periods of tilt—up to 20 seconds of arc—and short-term vibrations caused by local highway and rail traffic. Even solar and wind loads proved intolerable.

Site surveys resulted in the selection of the Hadley location because it offered unique and nearly ideal characteristics. The site is situated atop an underground "mountain" of igneous rock nearly 40 miles deep and physically independent of other adjacent geological formations. With its summit just at ground level, the mountain is surrounded by sandstone and clay overburden.

Seismic studies of the site area indicated a stability improvement over the nearby Northampton facility of better than 4,000:1, Kollmorgen engineers claim.

- **Hadley facility**—Heart of the Hadley test facility is the alignment chamber containing two 35-ton steel cylinders measuring 8 ft. in dia. x 46 ft. high. Essentially identical, they permit the alignment of two periscopes at roughly the same time. Located on bedrock, the silos are isolated from the weather enclosure and concrete floor. Even catwalks providing upper access to and between the towers are isolated from the test structures.

To assure silo thermal stability, the structures are covered with a polyeurethane-foam layer with an outer skin of reflective aluminum. The resulting temperature deviations in a horizontal plane are about 0.07°F over an 8-hour period.

Pendulous accelerometers are employed at the top and base of each silo to note any change from the gravity reference.

The only apertures in the building, besides doors, are portholes permitting use of the star Polaris or a remote terrestrial target for alignment references.

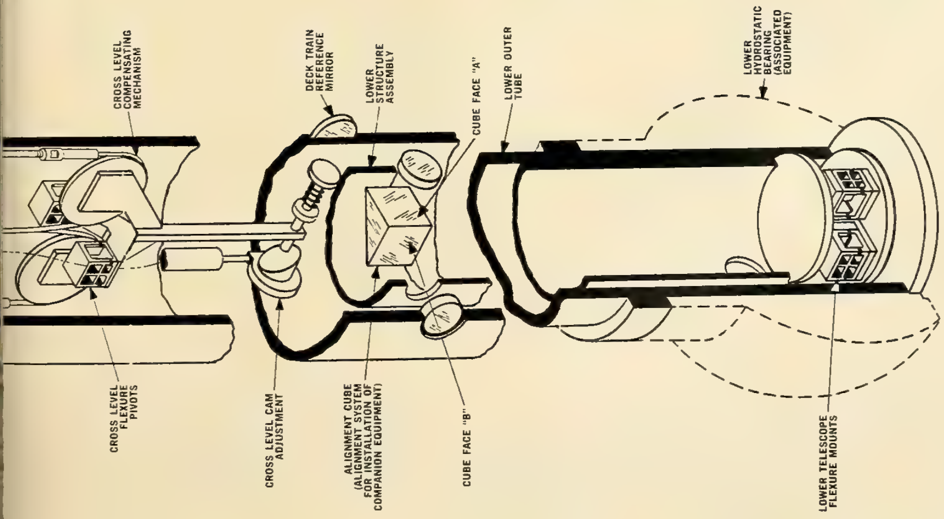
- **Alignment approach**—The basic periscope alignment scheme involves establishment of two parallel reference planes, 40 ft. apart. A line of direction in one plane is then located parallel to a line of direction in the other plane. The degree of parallelism must be consistent with the final periscope accuracy requirement.

To establish the parallel planes, the master reference axis in the scope is the train or azimuth axis, defined by the line joining the centers of two support bearings securing the periscope alongside the alignment silo.

The deck plane is normal to the master reference axis. The other plane is that generated when the line of sight is elevated and depressed and is normal to the deck plane.

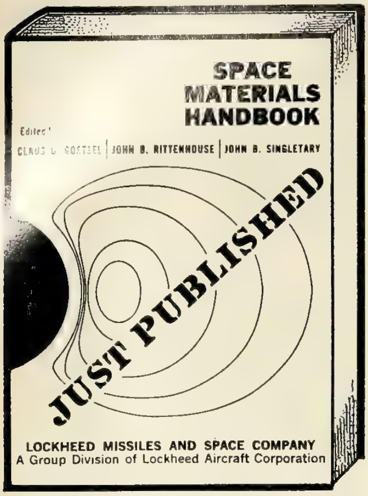
A bridge collimator is employed to clamp the periscope to the silo, duplicating the bearing restraint in a submarine installation. An auto-collimator views the periscope master-reference cube face and the entire bridge collimator test fixture is gravity referenced.

By adjusting the lower end of the telescope until an autocollimated image is returned from the two cube faces, the periscope optical axis and the bearings


CROSS LEVEL COMPENSATING MECHANISM
DECK TRAIN REFERENCE MIRROR
LOWER STRUCTURE ASSEMBLY
CUBE FACE "A"
LOWER OUTER TUBE
LOWER HYDROSTATIC BEARING (ASSOCIATED EQUIPMENT)
CROSS LEVEL FLEXURE PIVOTS
CROSS LEVEL CAM ADJUSTMENT
ALIGNMENT CUBE (ALIGNMENT SYSTEM FOR INSTALLATION OF COMPANION EQUIPMENT)
CUBE FACE "B"
LOWER TELESCOPE FLEXURE MOUNTS

OPTICAL configuration and light path of Navy's Type 11A celestial tracking periscope are shown in this simplified drawing. The cross-level control rod assembly and the even number of reflecting surfaces in the head optics are used to make the optical line of sight insensitive to elevation-angle error caused by mast flexure.

SPACE MATERIALS HANDBOOK



SPACE MATERIALS HANDBOOK

Editors
CLAUS G. GOETZEL | JOHN B. RITTENHOUSE | JOHN B. SINGLETARY

JUST PUBLISHED

LOCKHEED MISSILES AND SPACE COMPANY
A Group Division of Lockheed Aircraft Corporation

Provides in one reference volume — a collection and interpretation of the effects of space environments on materials.

An outstanding aid to all scientists and engineers engaged in designing and constructing spacecraft.

The Space Materials Handbook was first prepared as an Air Force sponsored report in 1961 by a team of twenty-five Lockheed Missiles and Space Company scientists in an attempt to collect and analyze the wealth of materials data which had been accumulated in support of several Air Force satellite programs. It was soon recognized that environmental effects data from other sources should also be incorporated to make the volume of most usefulness.

The presentation is divided into four broad parts: the space environment, effect of the environment on materials, materials in space (materials applications), and biological interaction of materials.

Examine this outstanding reference work for 10-Days without obligation. Write to Dept. A-457 or fill in coupon below. C. 650 pp (1965) $15.00

**Addison-Wesley Publishing Co., Inc.
Reading, Mass. 01867**

Available on 10-Day Free Examination

Please send .... copies of "Space Materials Handbook" @ $15.00 for my inspection and approval.

Name

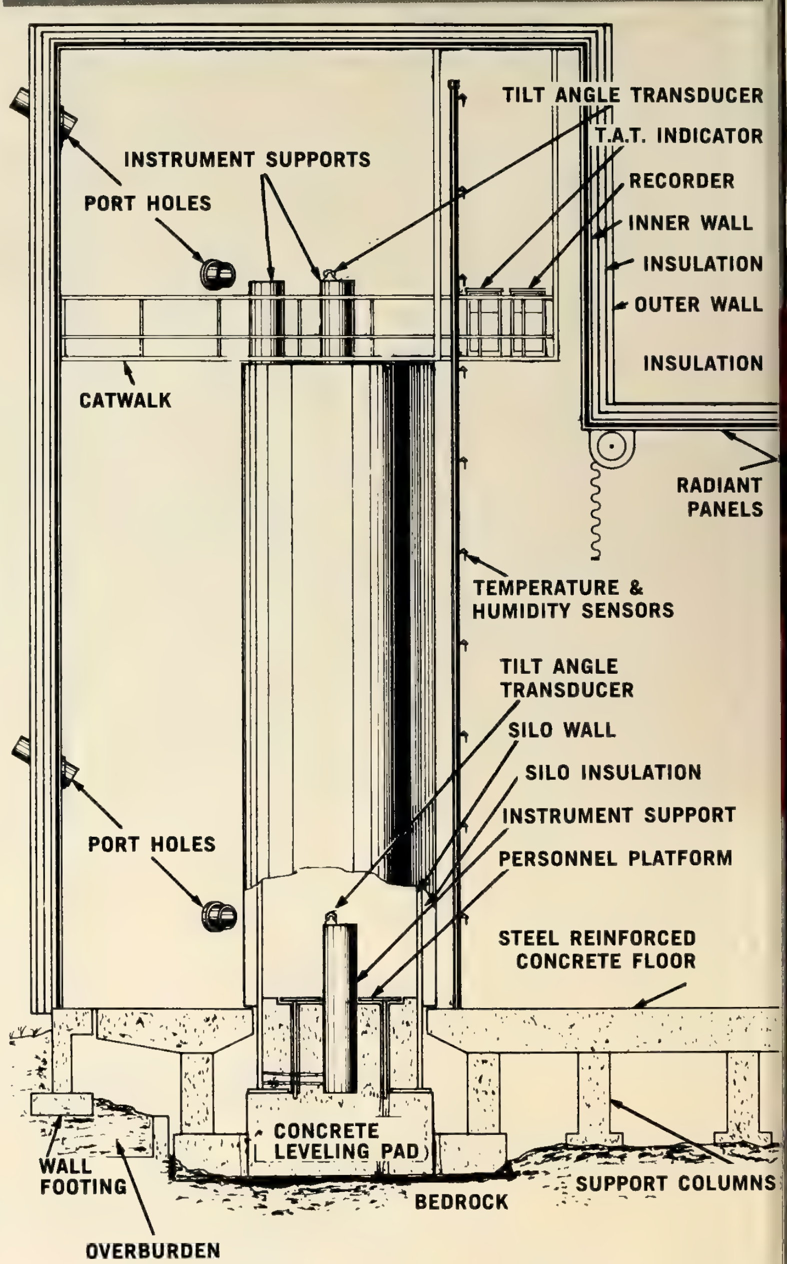
Company

Address

City State

☐ Bill me ☐ Bill my company (We pay postage if you enclose check — same inspection privilege) A-457

Circle No. 20 on Subscriber Service Card


TILT ANGLE TRANSDUCER
T.A.T. INDICATOR
INSTRUMENT SUPPORTS
RECORDER
PORT HOLES
INNER WALL
INSULATION
OUTER WALL
INSULATION
CATWALK
RADIANT PANELS
TEMPERATURE & HUMIDITY SENSORS
TILT ANGLE TRANSDUCER
SILO WALL
SILO INSULATION
INSTRUMENT SUPPORT
PORT HOLES
PERSONNEL PLATFORM
STEEL REINFORCED CONCRETE FLOOR
CONCRETE LEVELING PAD
WALL FOOTING
SUPPORT COLUMNS
BEDROCK
OVERBURDEN

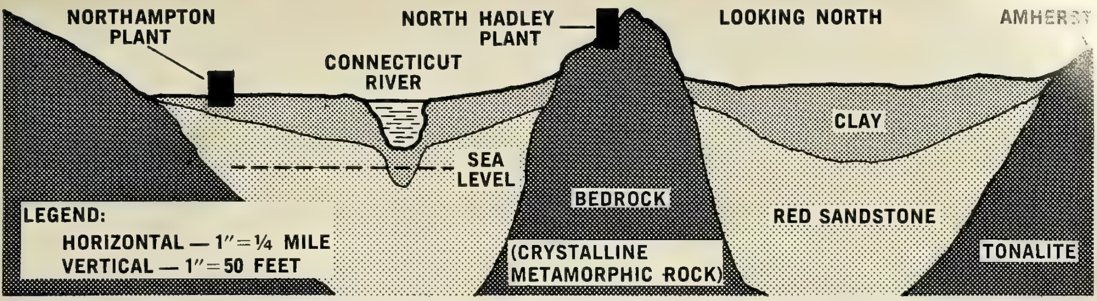
CROSS-SECTION of the ultra-stable Type 11A periscope test facility shows outer structure, one of two silos (periscope alignment fixtures) and the isolated concrete pads and flooring. Kollmorgen developed the installation for the Navy.

mechanical axis relationship can be established.

The same bridge collimator is used in both vertical and horizontal positions without degrading accuracy through the use of load cells to counteract normal bridge deflections.

In a typical periscope alignment, two days are required to align the master cube to the tube mechanical axis and collimate the lower section to the rest of the tube.

• **Periscope design**—(Refer to the accompanying drawing showing the op-


NORTHAMPTON PLANT
NORTH HADLEY PLANT
LOOKING NORTH
AMHERST
CONNECTICUT RIVER
CLAY
SEA LEVEL
BEDROCK
RED SANDSTONE
LEGEND:
HORIZONTAL — 1″=¼ MILE
VERTICAL — 1″=50 FEET
(CRYSTALLINE METAMORPHIC ROCK)
TONALITE

KOLLMORGEN'S Hadley test facility, situated atop a 40-mile-deep underground "mountain" of igneous rock, provides a 4,000:1 stability improvement over previous site at Northampton, Mass.

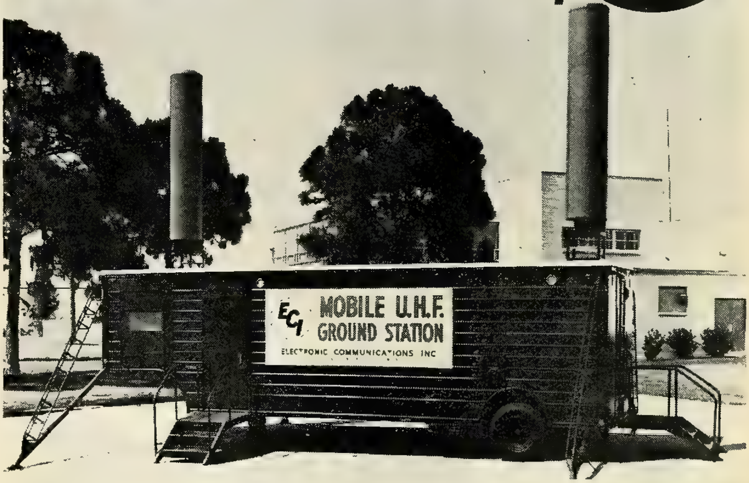
tical configuration and light path.) A principal problem with any periscope and particularly with a high precision system is that of cross-level misalignment due to mast flexure.

Such errors have been negated in the Kollmorgen design of the Type 11A scope through use of a pair of Invar control rods and a cross-level compensating mechanism. The rods extend from the head assembly downward between the inner and outer tubes to the compensator assembly, just below the eyepiece box. The rods slave the head-assembly optics to the telescope optics maintaining the rotational axis of the elevation-angle mirror normal to the axis of the telescope and parallel to the deck plane. The rods, basically, serve as a set of two opposing legs of a parallelogram. Equal tension is maintained between the legs and the connecting head and compensating assemblies.

To verify alignment during operation, an auto-collimation control is employed that depresses the scanning mirror (in the head assembly) to a position normal to the optical axis. In this position, the line of sight is reflected back down the telescope. The operator can then view reflected vertical-reticle lines to determine misalignment. If a correction is necessary, adjustment of the cross-level controls alters the control rods and, thus, the parallelogram angles, until the error is zeroed.

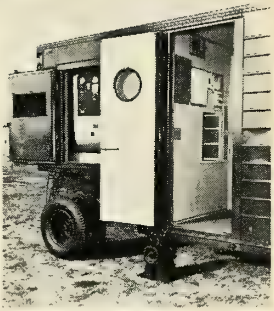
Because the system employs an even number of reflecting surfaces in the head assembly, the optical line of sight is insensitive to elevation-angle error due to mast flexure in the level plane. (The maximum expected flexure under operating conditions is 22 arc minutes but the constant deviation derived from the optical configuration is the same for any error within the physical limits of the system.) ■

TRAILERS FOR THE SPACE AGE by DORSEY®

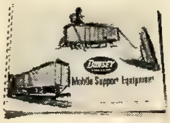

ECI MOBILE U.H.F. GROUND STATION
ELECTRONIC COMMUNICATIONS INC

ECI communication equipment housed in Dorsey Trailers operates as highly reliable utility-type, all-weather ground stations for air-borne UHF multiplex systems. The vans are air conditioned and insulated for comfort in hot climates or sub-zero temperatures, sealed over-all against extremely heavy rains and equipped with sway braces to withstand 150 M.P.H. wind. Other features installed at the factory included generators and special electrical circuits.

Dorsey has built a record of reliability during two decades of handling defense assignments. Our engineers bring to initial-stage conferences valuable design experience and knowledge of time and cost factors. Can we help you?



This full trailer built by Dorsey for Electronic Communications, Inc., has steerable front wheels, leveling jacks and insulated windows.


Dorsey
Mobile Support Equipment

Send for brochure
"Mobile Support Equipment"

DORSEY
RESEARCH & DEVELOPMENT CENTER

Special Products Division
DORSEY TRAILERS / ELBA, ALABAMA
A Subsidiary of The Dorsey Corporation

Circle No. 8 on Subscriber Service Card

GE-Developed Elastomeric Re-entry Shielding Bids for Mars Mission Role

by John F. Judge

King of Prussia, Pa.—The latest member in a family of silicone elastomeric re-entry shield materials being perfected at General Electric's Valley Forge Space Technology Center may be good enough for Mars missions.

The Elastomeric Shield Material (ESM 1004) is a fiber-filled, foamed silicone elastomer available over a density range of 23 to 66 lbs. per cu. ft. The composition and process is proprietary with GE, but the fiber is known to be randomly oriented in the material.

In addition, although fairly small concentrations of fibers are used, any amount can be added without having the mixture go thixotropic. The nature of the fiber is also proprietary.

The composition has been extensively tested in the labs and flown in certain experiments using the *X-15* rocket plane. The material is extremely easy to apply and can be refurbished after given missions or if damaged during ground handling.

The properties of ESM 1004 were not disclosed except that they are superior to the rest of the ESM 1000 series of materials in strength, toughness, application, and in high-temperature properties.

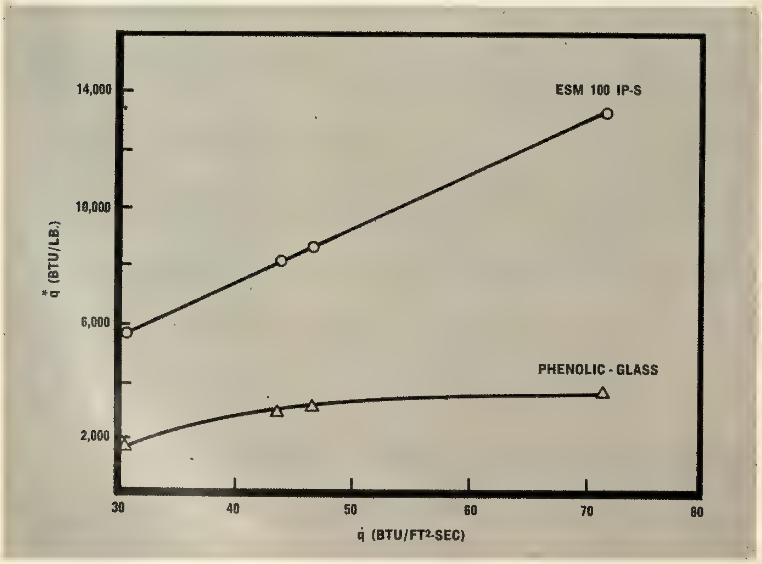
- **Tougher thermal situation**—The ESM 1000 family is GE's answer to the problem of thermal protection for lifting re-entry bodies. While the heat flux for a lifting re-entry vehicle is low (2 to 450 Btu/ft.^{2}-sec.), the total integrated heating is an order of magnitude higher than that experienced by vehicles in ballistic re-entry.

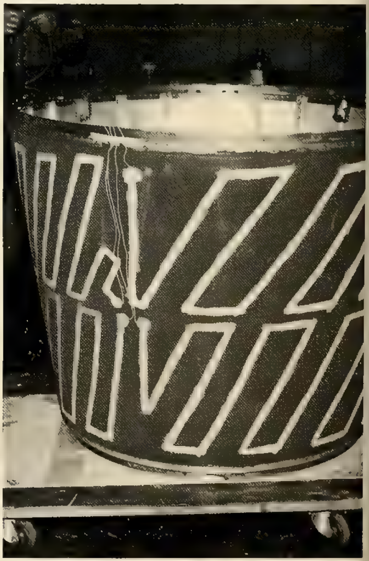
In addition, the non-axisymmetrical shapes envisioned for lifting re-entry configurations coupled with the presence of fins and control surfaces tend to make prediction of aerodynamic heating considerably more difficult than that for ballistic modes.

The environment also poses different requirements on the ablation heat protection system. The thermal insulative properies, shape stabiliy and ablative performance are of varying importance depending on vehicle location.

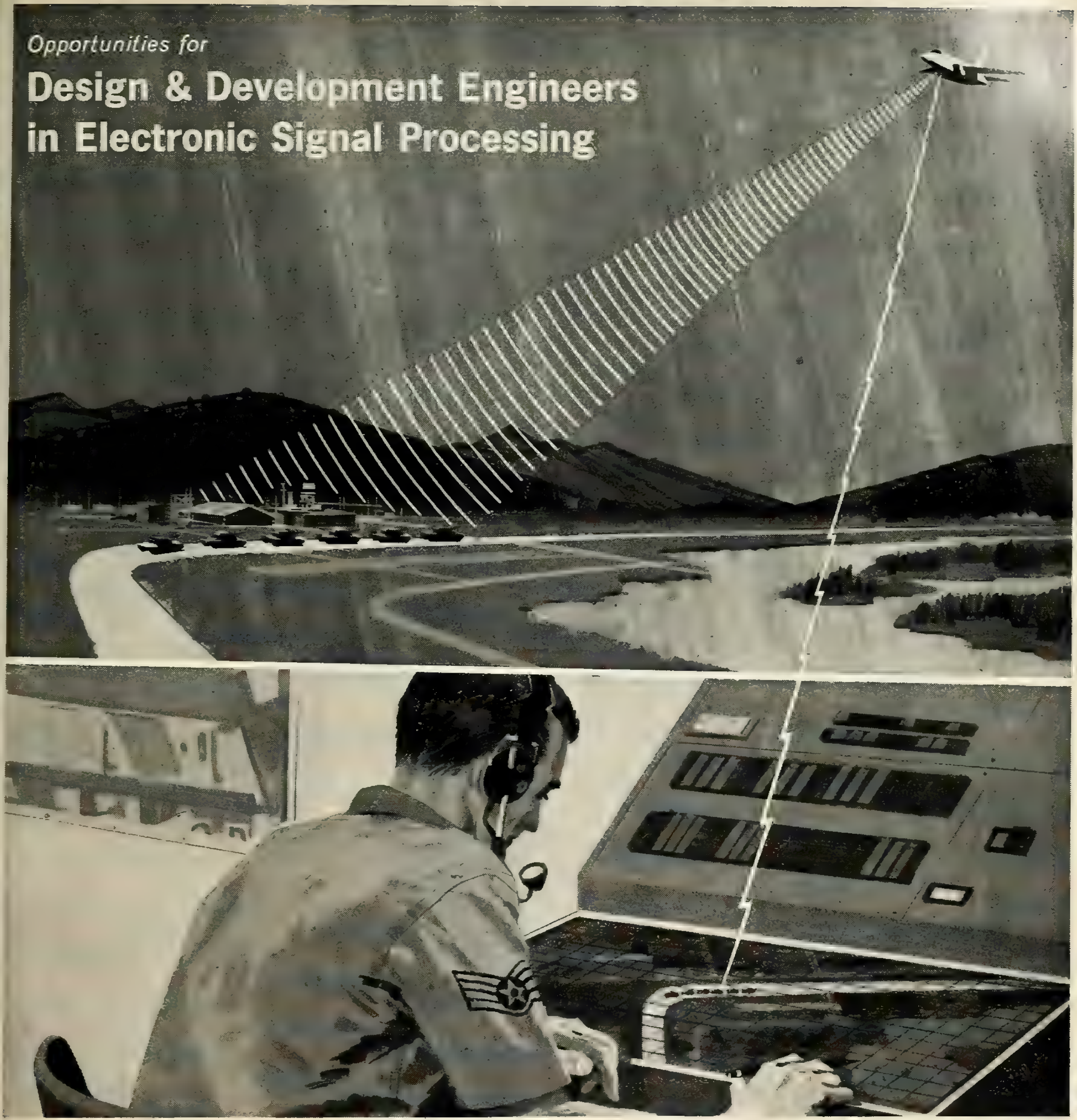
The ESM 1000 series work has been going on for about three years at the Aeromechanics & Materials Laboratory Operation, Re-entry Systems Dept. The first member of the family, ESM 1000 is a pure silicone foam elastomer.

The second, ESM 1001, is silicone





LEFT: Results of a recent evaluation of the performance of ESM 1001 PS in a range of heating conditions applicable to re-entry satellite vehicles. Test was run in GE Hypersonic Arc Tunnel. The elliptical model was tested in a slantindicular position to give heating rates of 46, 43 and 31 Btu/ft.^{2}-sec. (cold wall) across the surface. Phenolic-glass was used as a reference material. RIGHT: Rigid aluminum frustrum section covered with ESM 1001 PS shown being instrumented for thermal cycling at ±300°F.


Opportunities for
Design & Development Engineers in Electronic Signal Processing

Design and development activities in the field of Electronic Signal Processing are rapidly expanding today at HUGHES Aerospace Divisions.

Development of systems utilizing advanced correlation and matched filter techniques for *High-Resolution Radar, Acoustic Detection & Classification* and *Pulse Doppler Radar* is being accelerated.

Specialists in Signal Processing, Circuit Design, Mechanical Design, Packaging Design, Performance Analysis and Project Engineering will be interested in the outstanding assignments now available.

Graduate engineers with experience in wide-band video amplifiers; high-resolution cathode ray tube circuits and applications (including ultra-linear sweep, gamma correction and dynamic focus); high-voltage power supplies; low-jitter timing circuitry; high-speed analog sampling circuitry; precision film transports; ultra-high speed film development; scan conversion systems; synthetic array radar systems; imagery recording, or similar fields—are invited to submit resumes.

For immediate consideration
please write:

Mr. Robert A. Martin
Head of Employment
HUGHES Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 20, Calif.

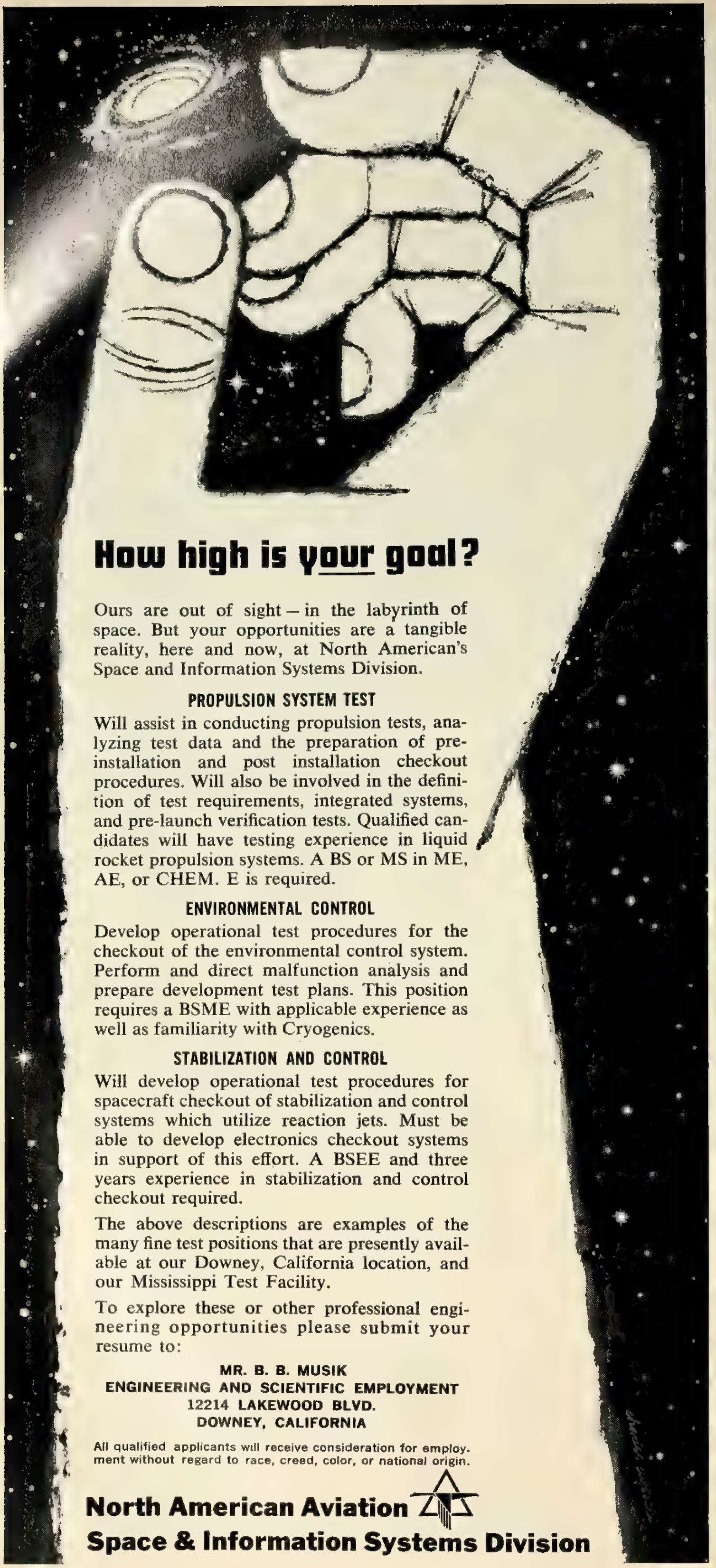
Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS

An equal opportunity employer

U. S. CITIZENSHIP REQUIRED



How high is your goal?

Ours are out of sight — in the labyrinth of space. But your opportunities are a tangible reality, here and now, at North American's Space and Information Systems Division.

PROPULSION SYSTEM TEST

Will assist in conducting propulsion tests, analyzing test data and the preparation of pre-installation and post installation checkout procedures. Will also be involved in the definition of test requirements, integrated systems, and pre-launch verification tests. Qualified candidates will have testing experience in liquid rocket propulsion systems. A BS or MS in ME, AE, or CHEM. E is required.

ENVIRONMENTAL CONTROL

Develop operational test procedures for the checkout of the environmental control system. Perform and direct malfunction analysis and prepare development test plans. This position requires a BSME with applicable experience as well as familiarity with Cryogenics.

STABILIZATION AND CONTROL

Will develop operational test procedures for spacecraft checkout of stabilization and control systems which utilize reaction jets. Must be able to develop electronics checkout systems in support of this effort. A BSEE and three years experience in stabilization and control checkout required.

The above descriptions are examples of the many fine test positions that are presently available at our Downey, California location, and our Mississippi Test Facility.

To explore these or other professional engineering opportunities please submit your resume to:

MR. B. B. MUSIK
ENGINEERING AND SCIENTIFIC EMPLOYMENT
12214 LAKEWOOD BLVD.
DOWNEY, CALIFORNIA

All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

North American Aviation
Space & Information Systems Division

foam plus an asbestos filler. The third is ESM 1001 PS, the silicon elastomeric foam with a phenolic-glass honeycomb matrix. Variations on this material include splitting the honeycomb modules, leaving a material with an essentially oriented reinforcement.

The last member is ESM 1004, the fiber-filled silicone elastomeric foam.

Each grouping in the family represents an improvement. While the details of the fiber-filled material are company-confidential, the split-honeycomb ESM 1001 PS can serve as an example of the areas of application and capability of the ESM 1004.

- **Environment compatibility**—One major problem in the development of the family was the elimination of failure mechanisms during an anticipated mission temperature cycle of ±300°F —without detrimentally affecting the thermal performance of the shield. The inclusion of a phenolic-glass honeycomb to the composite was done originally to improve the thermomechanical compatibility of the system and upgrade resistance to re-entry shear forces.

Initial analysis indicated this same matrix could increase the compatibility problem in thermomechanical performance due to its system-dominating, complicated, biaxial behavior and expansion characteristics.

The elastomeric filler could also be improved by using a phenyl substituted silicone, which retains its elastic properties to much lower temperatures than the original methyl silicone polymers used.

In the sampling tests, neither the controls nor the specimens failed at the +300°F soak area. All failures occurred on the cold and propagated at the adhesive bond. Data indicated this was due to the interacion beween the resin and matrix.

GE specialists changed to a discontinuous matrix wherein the honeycomb is cut through its thickness so that the honeycomb tape is completely discontinuous at each cell. This, plus the phenyl substitution, brought the system to the desired low temperature capability at −300°F.

The modifications also improved the large-scale fabricability of the system. Rigid honeycomb "saddlebacks" when bent in any direction and cannot normally be formed to complex curves. But the foamed silicone in the discontinuous, or split, matrix acts like a rubber blanket and readily conforms to almost any shape.

This ease of configuration forming in the ESM 1001 PS (split honeycomb) material is improved in the fiber-filled form ESM 1004.

The split matrix still retains the original function of the matrix—an aid in resisting aerodynamic shear forces.

• **Heavy test program**—GE specialists ran tests on all properties of ESM 1001 PS, including thermal conductivity, specific heat, thermogravimetric analysis, thermal expansion and shield bond characteristics. Stress-strain tests indicate that the material has passed through its ductile/brittle transition at —240°F, but other data shows this temperature is actually about —180°F.

In the environmental exposures tests, samples of ESM bonded to aluminum plates were subjected to 0.1 gram particle impacts at velocities up to 30,000 fps and at temperatures down to —200°F. Although the particles penetrated both the shield and base plate, the ESM neither shattered or delaminated from the baseplate.

Vacuum-temperature runs were made only as a quantitative measure of the effect on properties. Compression specimens were exposed for 14 days at 250° F and 5 x 10^{-5} Torr. The weight loss was less than 1% and no change in compressive properties was detected.

• **Fabrication and Layup**—A rigid aluminum frustrum section of a vehicle was selected for manufacturing scale-up and thermal cycle qualification. The base diameter is 41 in., the top diameter 30.1 in., and the overall height is 34 in.

After proper priming, the split honeycomb was placed in a simple, sheet metal female mold onto the evenly distributed resin. The filler material was foamed and cured in place.

After foaming and curing, excess material was removed and the shield system dimensionally stabilized by postcuring. Segments were cut to size with a lofting pattern.

After proper surface preparation of both the shield and structure, the shield segments were bonded to the substructure with an elastomeric material. Segment edges were joined by bonding wedge segments in the controlled gap through foaming the filler material in place in the gap and by butting the joints. The objective here was to determine the best method or alternate approach to be used in joining the segments.

A small nose cone section was also fabricated in a similar manner to define the proper procedure when forming onto a structure with a small radius. No problems were encountered.

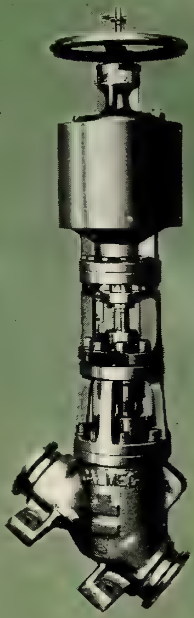
GE experts feel the ESM 1000 systems can be further optimized through continued development and lessons learned from actual flight experience. The elastomeric materials may well provide the basis for the next generation of thermal protection systems. In addition, the systems could also provide the basis for improved solid rocket insulation liners and some exploratory work has been done in this area. ■

10,000 PSIG Y-Globe Valves for high flow requirements

A series of Y-globe valves for 10,000 PSIG working pressure operate with flow coefficients approaching those of gate valves. At 10,000 PSIG operating pressure, less than 35 PSIG cylinder pressure actuates the valves; less than 160 in.-lbs. handwheel torque opens and closes the valves within 12 revolutions maximum.

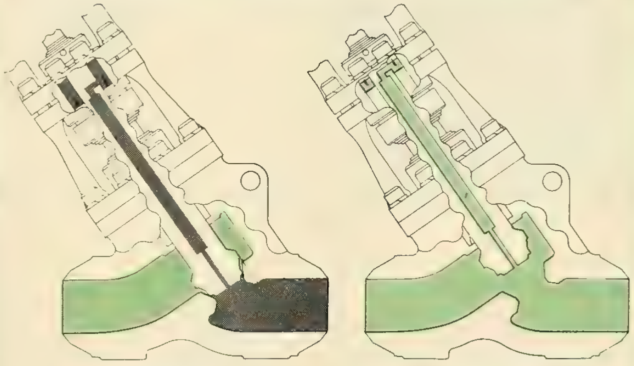
To assure smooth control in severe high-pressure applications, a compensating pressure disc assembly facilitates fast, cushioned stroking when opening and closing the valve with high differential pressures and velocities across the valve port.

CPD series valves are available in cylinder operated, manual operated and cylinder operated with auxiliary handwheel configurations in sizes from 1½" through 8" for operation over a temperature range of −452°F to +750°F.



Write for 8-page brochure describing operation and specifications.

COMPENSATING PRESSURE DISC OPERATION



CLOSED POSITION
OPEN POSITION
DIRECTION OF FLOW ⇒

Calmec compensating pressure disc assembly overcomes severe high pressure control problems by eliminating undesired line pressure forces acting against the valve stem and against both upstream and downstream sides of the internal valve plug. Equilibrating pressure on the valve plug and piston provides a cushioning effect and assures smooth stroking of the valve.
PATENTS PENDING

CALMEC

CALMEC MANUFACTURING CORP.
5825 District Boulevard • Los Angeles 22, Calif. • (213) 588-6204 • TWX (213) 773-5796

Circle No. 9 on Subscriber Service Card

AIRCRAFT ENGINEERS

Seven great aircraft programs open the door to career advancement

More than ten years of intensive engineering activity are on the Douglas agenda. Coming up are more advanced DC-8s and DC-8Fs· commercial, business and military versions of the new twin-jet DC-9; a tremendous developmental program on the C-5A, biggest jet in the world; advanced versions of the Navy A-4E and its two-place training counterpart, the TA-4E; and advanced aircraft. And there are other programs we can't talk about.

Right now we are urgently seeking aircraft engineers with BS or advanced degrees who have experience in any of the following: Aerodynamics; Stress Analysis; Load Analysis; Dynamic Analysis; Electrical Design; Structures Design; Power Plant — Thermo-Mechanical; Flight Test Instrumentation; Flight Test Data Analysis; Reliability; Advanced Systems Engineering. Openings include a number of senior positions.

For full information, please send resume to Mr. C. C. Carrico, Professional Employment, Douglas Aircraft Company, 3855 Lakewood Boulevard, Long Beach, California. An equal opportunity employer.

DOUGLAS
AIRCRAFT GROUP

The Industry Week

Mergers and Acquisitions

International Telephone and Telegraph Corp. has concluded acquisition of the assets of the Clevite Corp's Semi-Conductor Div. in Waltham, Mass. ITT will transfer usuable equipment of the Clevite operation to its own Semi-Conductor Div. activities in Lawrence, Mass., and West Palm Beach, Fla. In the same move ITT obtained Clevite's research and development facility in Palo Alto, Calif. . . . *Baifield Industries, Inc., Gardena, Calif., is merging its wholly owned Missiles Systems Corp. subsidiary in Carrollton, Tex., into the parent company. Baifield itself operated under the Missiles Systems name until last year.* . . . The acquisition of Associated Testing Co, by Walter Kidde & Co., Inc., has received a final okay from the stockholders of AT. Boards of the two firms approved the deal last month (M/R, Jan. 18, p. 37). . . . *Radiation Incorporated, Melbourne, Fla., has bought the North Electric Co.'s supervisory control product line marketed to private industry under the trade names Paricode ® and Locotrol.® The North industrial control systems are said to closely parallel the line of control, telemetering and display equipment Radiation currently produces for government markets. Radiation Inc. will form a new Industrial Control Div. to market the product line. A new facility will be built in Melbourne to engineer and produce the equipment.* . . . Hewlett-Packard Co. has signed an agreement with Datamec Corp. whereby Datamec will become a wholly owned subsidiary of H-P effective June 30. Datamec, which is located in Mountain View, Calif., makes digital magnetic tape units and other electro-mechanical equipment for data acquisition and processing equipment. . . . *Raytheon Co. has announced it has agreed on terms to merge Amana Refrigeration, Inc., of Amana, Iowa, with its operations. The move is aimed at providing Raytheon more strength and diversity in its commercial business through entry into the consumer market. Amana makes refrigerators, freezers and air-conditioning equipment.*

New Activities

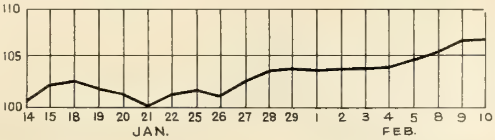
Space Ordnance Systems, Inc., El Segundo, Calif., has entered an expansion program aimed at producing a broadened range of products and a strengthened marketing organization, and including an increase in capital investment in the company by the Boston Capital Corp. SOS president William R. Dickie said, "We are directing our attention toward the entire range of interior ballistics and associated products and systems." SOS, since its formation in 1962, has concentrated on the field of small ordnance products and ordnance-actuated devices. . . . *Ling-Temco-Vought, Inc., headquartered in Dallas, has formed three new subsidiary corporations from eight operating divisions. The move is intended to provide increased flexibility for future growth. The divisions were grouped as follows, influenced by similarity of business and technology and geographic considerations: LTV Vought Astronautics, LTV Aeronautics, LTV Michigan, LTV Range Systems and Kentron Hawaii Ltd. will become LTV Aerospace Corp.; LTV Temco Aerosystems and LTV's Garland, Tex., operations will be combined as LTV Electrosystems, Inc.; and LTV Ling Electronics and LTV Altec will become known as LTV Ling Altec, Inc. Little change is anticipated in overall employment as a result of the move, and no changes are planned in the firm's top management.* . . . Microtran Co., Inc., Valley Stream, N.Y., has announced plans for beginning immediate operations at its new West Coast plant. Located in Gardena, Calif., Microtran West, Inc., will service West Coast aerospace customers of Microtran. The firm manufactures miniature transformers. . . . *Bunker-Ramo Corp. has created a new General Engineering Laboratory within its Defense Systems Div. The lab is to combine the functions of product design for the Western Technical Center, material and devices development, system effectiveness in engineering design and development, value engineering and cost reduction, and man-machine control system research.*

UAW To Meet on Aerospace Goals

Delegates from 53 United Auto Workers aerospace locals will meet this month to shape the union's general demands for this year's round of contract negotiations with the aerospace industry. With 125,000 aerospace workers as members, UAW is second only to the International Assn. of Machinists as a representative union in the defense/space business. The UAW's Aerospace Dept. will meet in San Diego, Calif., Feb. 25-26, only a month after IAM's Aerospace Conference met at Las Vegas, Nev., and is likely to outline a similar program for the coming negotiations. Included on the agenda will be discussions of wages and wage administration, union security, pensions and insurance, employment security and fringe benefits.

Missile/Space Stock Index

Tension in Viet Nam appears to have stimulated the defense stock market in spite of the fact that it caused "jitters" in some other stock areas. Individual large gains were also made by several of the monitored companies last week on the basis of favorable financial reports and the receipt of large contracts.



STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

Coating problems on
launcher arms, launchers,
flame deflectors, flame buckets

Specialized coating problems? The Rust-Oleum Corporation specializes in the research, development, and manufacture of coatings for particular problems in the missile and aircraft industry. Skilled Rust-Oleum specialists and technical service personnel are available to work hand-in-hand with you and your organization. May we hear from you?

RUST-OLEUM CORPORATION
2475 Oakton St. • Evanston, Ill.

Forty years of industry proof.

Distinctive as your own fingerprint.

RUST-OLEUM®
STOPS RUST!®

Circle No. 10 on Subscriber Service Card

contracts

AIR FORCE

$3,100,000—**Hercules Powder Co.,** Magna, Utah, to manufacture stage III *Minuteman* missile motors.

$2,788,000—**International Business Machines Corp.,** Washington, D.C. and Omaha, Neb., for work on developing improved computer programming techniques.

$1,846,451—**Radio Corp. of America,** West Palm Beach, Fla., for purchase of electronic data processing equipment it now leases.

$1,500,000—**North American Aviation, Inc.,** Anaheim, Calif., for continued production of components for an improved *Minuteman* missile guidance system.

$1,142,097—**Hayes International Corp.,** Birmingham, Ala., for tow targets for use in air-to-air missile-firing training.

$400,000—**Lockheed Aircraft Corp.,** Lockheed Propulsion Co., Redlands, Calif., for a development program aimed at the design and test of energy-controlled solid propellant rocket motors for air-launch applications.

$325,000—**University of Dayton,** Dayton, Ohio, for evaluation of refractory composites for application to critical areas of re-entry vehicles, advance turbine engines and rocket motor components.

$231,700—**Cornell Aeronautical Laboratories, Inc.,** Buffalo, N.Y., for ground and flight simulation evaluation for handling qualities criteria and human-transfer function data acquisition.

$230,207—**Garrett Corp.,** AiResearch Mfg. Co., Los Angeles, for non-reciprocating cooling techniques for space-based infrared sensors.

$190,000—**HRB Singer, Inc.,** State College, Pa., for 30 signal simulators for use in training operators of electronic equipment.

$93,456—**Ohio State University,** Research Foundation, Columbus, for R&D and experimental testing program on plasma nose temperature measurements on nose cones for high-velocity re-entry vehicles.

Dynalectron Corp., Washington, D.C., a multimillion-dollar three-year contract for technical and related services for White Sands Missile Range (amount not disclosed).

ARMY

$2,179,000—**R. E. Clarson,** St. Petersburg, Fla., for alterations to Complex 34, Cape Kennedy, for *Saturn IB*.

$1,300,000—**Belock Instrument Corp.,** College Point, N.Y., for the manufacture of *Hawk* simulator stations and modifications to existing equipment.

$789,444—**Alex Robertson Construction Co.,** Los Angeles, to begin renovation on first plant to manufacture *Shillelagh* missiles at Lawndale, Calif.

$672,000—**Belock Instrument Corp.,** College Point, N.Y., for *Hawk* simulator-trainor.

$468,277—**Bailes Sey Contractor Inc.,** Jacksonville, Fla., for extending the Merritt Island, Fla., industrial area.

$430,000—**American Elcon Inc.,** Cape Canaveral Fla., for furnishing and installing 25 miles of underground and aerial power lines.

$392,346—**Thiokol Chemical Corp.,** Huntsville Div., Huntsville, Ala., contract modification for a program to continue the effort in design of a high-performance propulsion system.

$370,000—**International Telephone and Telegraph Corp.,** Federal Laboratories, Nutley, N.J., to furnish three additional geodetic positioning satellites.

$288,015—**Heyl & Patterson Inc.,** Pittsburgh, for work on Complex 12, Cape Kennedy, for the service tower anchorage and tower system.

$250,000—**Smith & Sapp Construction Co.,** Orlando, Fla., for modification to launch Complex 16 for *Apollo* Service Module, Cape Kennedy.

$237,953—**American Elcon Inc.,** Cape Canaveral, Fla., for supplying and installing 12 coaxial cables in the central building and other buildings.

NAVY

$11,836,491—**Federal Electric Corp.,** Paramus, N.J., for maintenance of instrumentation systems on the Western Test Range.

$7,917,670—**Texas Instruments, Inc.,** Dallas, to make guidance equipment for *Shrike* missiles.

$7,729,119—**Hughes Aircraft Co.,** Fullerton, Calif., for radar antennas for installation aboard naval vessels.

$5,961,499—**Maxson Electronics Corp.,** Old Forge, Pa., to continue production of components of *Bullpup* missiles.

$2,506,348—**Raytheon Co,.** Oxnard, Calif., and Bedford, Mass., for engineering services and flight testing in connection with *Sparrow III* missile program.

$1,186,800—**Interstate Electronics Corp.,** Anaheim, Calif., for *Polaris* missile test instrumentation equipment.

$230,000—**Hercules Powder Co.,** Cumberland, Md., contract modification for increased level of effort for R&D of solid propellants.

$150,000—**General Electric Co.,** Pittsfield, Mass., for R&D program on the *Tartar* director MK 73 model and ancillary equipment.

NASA

$61,112,500—**North American Aviation, Inc.,** Anaheim, Calif., modification on an existing contract to provide ground support equipment for the *S-II* stage of the *Saturn V;* providing six sets, including automatic checkout, servicing, handling and auxiliary equipment.

$2,172,517—**Telecomputing Services Inc.,** Panorama City, Calif., for continued operation of computers and data transmission equipment at Michoud Operations, New Orleans.

$770,000—**Avondale Shipyard Corp.,** New Orleans, for converting a former Navy barge for use as a transporting vehicle for the *Saturn V* booster *(S-1C)* from New Orleans to Merritt Island, Fla., to be finished in August.

$330,950—**TRW/Space Technology Laboratories,** Redondo Beach, Calif., for routine support for *OGO-A* orbital operations.

$175,527—**Thiokol Chemical Corp.,** Elkton, Md., for *IMP* spacecraft rocket motor.

$143,500—**Reeves Instrument Co.,** Garden City, N.Y., for services and materials for a digital range modification system for S-band long-range radar.

$120,825—**United Corp.,** Timonium, Md., for service and material to operate *X-15* high range.

$80,000—**North American Aviation, Inc.,** Space & Information Systems Div., Downey, Calif., for preliminary design study of experiments pallet aboard *Apollo* spacecraft.

$61,385—**United Aircraft Corp.,** Hamilton Standard Div., Windsor Locks, Conn., for development of air evaporation water recovery system for spacecraft application.

$51,148—**American Scientific Corp.,** Alexandria, Va., for countdown display indicator.

$4,4205—**Standard Research Institute,** Menlo Park, Calif., for investigation of satellite radiation measurements and the atmospheric heat balance.

$23,496—**Rocket Research Corp.,** Seattle, for a feasibility study of long-life valveless pulse rockets for control of satellites and space vehicles.

Melpar, Inc., Falls Church, Va., a three-year contract to design and build a thin-film personal communications and telemetry system to be used by astronauts during activities outside the spacecraft (amount not disclosed).

INDUSTRY

$18,000,000—**Raytheon Company,** Lexington, Mass., from **Western Electric Co.,** Bell Telephone Laboratories, New York City, initia funding to develop the missile site radar fo the Army *Nike-X* anti-missile defense system

$6,000,000—**Arde-Portland, Inc.,** Paramus, N.J. from **Thiokol Chemical Corp.,** Wasatch Div. Brigham City, Utah, for production of rocke nozzles for the Stage I motors from *Minuteman*

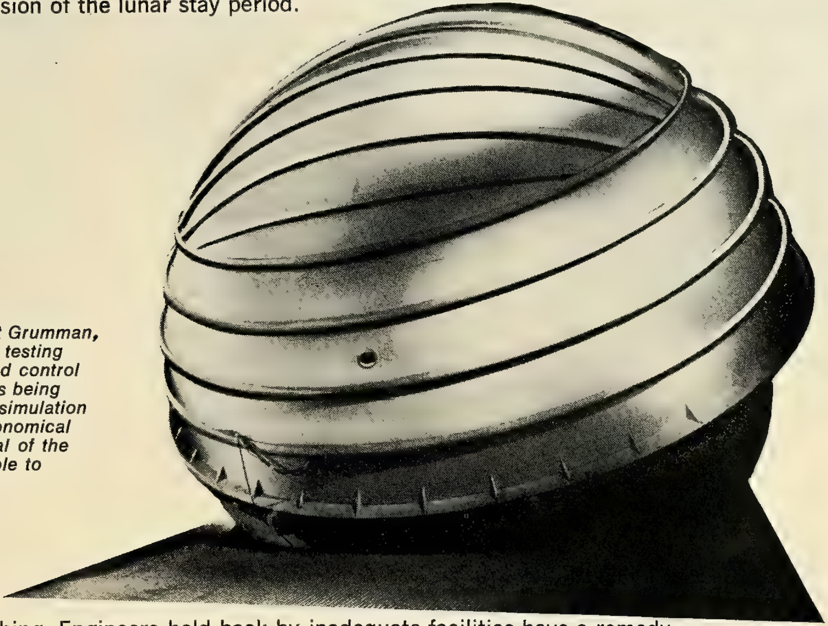
$4,400,000—**Kaiser Aerospace and Electronic Corp.,** San Leandro, Calif., from **Thiokol Chemical Corp.,** Wasatch Div., Brigham City, Utah to produce movable nozzles for the Stage motor of *Minuteman*.

$1,000,000—**Microwave Associates, Inc.,** Burlington, Mass., from **Raytheon Co.,** Lexington Mass., initial funding for design and development of precision solid-state microwave equipment in connection with *Nike-X*.

FACILITIES AT GRUMMAN

will quicken the professional pulse. Up to the minute often original equipment and facilities are there. At the engineers' fingertips speeding aerospace development in ground support and flight testing. Cutting the time gap as new theories and designs are subjected to immediate experimental verification. Here are a few of them:

▪ Hydroacoustical Tank for underwater acoustics and instrumentation. ▪ Plasma Generator for experimental research in Plasma Physics. ▪ Three Axis Flight Simulator for pre-flight evaluation. ▪ Centrifuge for acceleration testing of vehicle components. ▪ Environmental Space Chamber for simulating vacuumized thermal conditions. ▪ Anechoic Chamber for echo-free radio testing and aircraft antenna work. ▪ Rendezvous and Docking Simulator for training of astronauts in the control of the LEM (Lunar Excursion Module) at the conclusion of the lunar stay period.



Designed and fabricated at Grumman, the Dynamic Simulator for testing spacecraft stabilization and control systems within a vacuum is being used extensively for flight simulation of the OAO (Orbiting Astronomical Observatory) and is typical of the advanced facilities available to our engineers.

It all adds up to one thing. Engineers held back by inadequate facilities have a remedy.

See these specific opportunities at Grumman.

Systems Co-ordination Engineers—will coordinate a program that organizes, validates and controls the overall functional requirements, of an advanced manned spacecraft project fulfilling project objective as prescribed by the procuring agency. These functional requirements are translated into over-all vehicle performance and design requirements, establishing systems parameters from which the vehicle, its major subsystems, and support equipment are designed. Task assignments include: internal and external liaison with design specialists & systems personnel & direction of the incorporation of established requirements into top systems and vehicle specifications. Applicants should possess a BS or MS in ME, EE or Physics and a minimum of 3 years of systems analysis or integration experience in a major systems effort.

Systems Analysis Engineers—to determine specific systems design criteria and performance requirements from basic mission objectives and theoretical considerations and to define and follow through on studies required to achieve compatibility among the major space vehicle functions of guidance and control, communications, life support, etc. Other assignments include system optimization studies with respect to overall vehicle performance, reliability, weight, etc.; determination of optimum allocation of error budgets among major subsystems; development of mathematical models of spacecraft subsystems and verification of adequacy of these models against dynamic operation of actual equipment; determination of systems oriented objectives for simulation programs and interpretation of simulation results; and the analysis of laboratory and field test results of vehicle systems and the determination of effects upon overall system performance. Applicants should possess a good working knowledge of the theory and operation of one or more of the following equipment areas: navigation and guidance, airborne radar, space propulsion, airborne stability and control, and airborne digital computers.

Systems Engineer—Facility and Services—BS or advanced degree with a minimum of 2 years experience in establishing the requirements for facilities and the criteria for the evaluation of existing facilities. Applicants will be required to survey tests and operational sites both ashore and afloat to verify weapon system compatibility with existing facilities and support equipment. Ability to recommend and/or originate solutions to preclude potential interface difficulties is necessary. Recent military experience and/or good working knowledge of military organization desirable.

Programming Analysts — Over 5 years experience in programming scientific problems on general purpose and special purpose computers. Competency in real time system programming, problem formating, mathematical modeling, assemblies, compilers, executive control routines, and simulation techniques. BS or MS in Science, Mathematics or Physics, Systems engineering orientation and space project background most desirable. IBM 7094 experience in depth.

Computer Programmers—Requires 2 years minimum Physics, Math or Engineering background with experience in FORTRAN and scientific programming. Will develop digital computer software for test data reduction on pseudo real-time system. Work includes analysis of programs requirements, developing flow diagrams, programming, debugging, documentation, and production follow-up of problems. Also requires understanding of the complete data system from recording to final results.

Senior Support Systems Engineers—BSEE with 5-10 years experience in Electronic Support Systems for Military aircraft, missiles or spacecraft. Duties consist of design, development, and integration of complex electronic support equipment. Background in radar, servo mechanisms, analog/digital interfaces or digital computers essential.

To arrange an immediate interview,
SEND RESUME to
Mr. P. M. Van Putten,
Manager Engineering Employment,
Dept. GR-86

Grumman

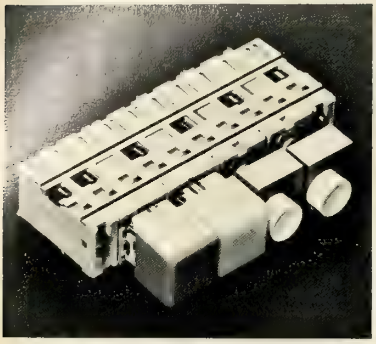
GRUMMAN
AIRCRAFT ENGINEERING CORPORATION
Bethpage • Long Island • New York

(An Equal Opportunity Employer)

Circle No. 11 on Subscriber Service Card

New Product of the Week:

Switch/Display Matrix



Honeywell's Micro Switch Div. has introduced a compact, new "KB" series switch/display matrix which combines a modular plug-in family of devices for encoding, power transfer, and panel indication. The firm sees applications for the concept in many different computer-controlled systems, ground-support-equipment, missile guidance control, and various communications systems.

The KB system uses interlocking mounting bars to build up a rigid box girder type of structure which actually gains strength as modules are added. The two key components include encoding switches used for alpha-numeric data entry to the equipment the KB matrix is tied to, and power switches that, in effect, provide control functions. The encoding switches are momentary-action devices with an eight-channel output representing eight binary bits. The power switches are either two- or four-pole models with momentary or alternate action.

The system is configured with a color-coded light display to indicate status.

Circle No. 151 on Subscriber Service Card

Epoxy Silver 'Solder'

A conductive epoxy silver "solder," E-Solder 3500, has been developed by Epoxy Products, Inc.

The one-component, heat-cure system requires no mixing before use. When heated to a temperature of 100°C or higher, the solder melts to a soft, non-flowing, thixotropic mass. Continued heating will cause the material to cure to a solid with a volume resistivity of 0.001 ohm-cm. It is available as powder or in preforms and may be cured at temperatures from 100° to 200°C with typical cure schedules of 30 minutes at 150°C or one hour at 125°C.

Circle No. 152 on Subscriber Service Card

Component Oven

A vacuum oven for processing electron tube and semiconductor components has been developed by ABAR Corp.

The front-loading unit uses a series of horizontal heating elements, each radiating directly upon rack-supported trays. The arrangement insures isothermal conditions throughout the oven and reduces heat-up time to five minutes, the firm says. The unit is capable of a pump-down to a vacuum of 1 x 10^{-5} torr in less than 20 minutes.

Because of the close proximity of the heating element to the work load, necessary temperature differential is reduced to less than 50°C, permitting close temperature control of the charge, company spokesmen say.

The oven is available in sizes up to 5 cu. ft. with a selection of heating element materials depending on temperature requirements.

Circle No. 153 on Subscriber Service Card

Voltage Reference Supply

A miniature voltage reference supply with a time stability of 5 mv per year is being marketed by Scintillonics, Inc. The unit measures 2.5 x 3 x 4.12 in. and weighs less than 2 lbs.

The series VR/20 unit has an output of 45v dc (adjustable to ±450 mv), 0 to 35 ma. Load regulation is 0.01% and line regulation is 0.002% from 105 to 125 v input. Other supplies may be furnished at any voltage in the range from 10 to 50v.

Circle No. 154 on Subscriber Service Card

Adiabatic Calorimeter

Thermo-Physics Corp. is marketing the Model AC-1000 adiabatic calorimeter, an instrument developed for use in determining specific heat and heat of reaction of materials.

The device can be used with metals, plastics and ceramics and offers accuracies of ±2% from −300 to 400°F and ±5% from 400 to 700°F. In operation, a material sample between 30 and 100 grams is mounted within a

What's the shortest distance between these 2 points?

Los Angeles ✱ Cape Kennedy
San Diego • Houston • New Orleans • Melbourne

National's direct line.

We call it our "Rocket Run." It's the only direct jet service between the major space centers of the west and Melbourne (closest airport to Cape Kennedy.)

You jet between Los Angeles and Melbourne without changing planes. National also serves the key space age cities along the east coast.

Is this any way to run an airline? You bet it is.

Jet National
coast to coast to coast

Circle No. 12 on Subscriber Service Card

flat box calorimeter and heated electrically.

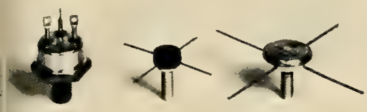
The calorimeter is thermally isolated from the environment by use of a vacuum and an automatically matched adiabatic guard heater enclosure. Liquid nitrogen is circulated through an integral coil to produce the initial temperature of —300°F. The energy supplied to the calorimeter serves only to raise the temperature of the calorimeter plus sample; the heat supplied per degree rise in temperature represents the heat capacity of the calorimeter plus sample. Subtracting the predetermined heat capacity of the calorimeter from the total and dividing by sample mass yields the specific heat of the sample.

Circle No. 155 on Subscriber Service Card

Light-Weight Transistor

TRW Semiconductors, Inc., is marketing a transistor which uses a new encapsulation method of molding a cap around an exposed ceramic heat sink. The device uses a silicon molding compound, developed by Dow Corning Corp., that cuts unit weight to one-third that of comparable metal enclosed transistors. The packaging technique is expected to make solid-state transistors competitive in price with tubes in commercial high-frequency devices, the firm says.

The Model PT3690 is rated at 10 watts, 150 mc, with testing now underway at frequencies up to 400 mc. Total dissipation at 25°C case temperature is 20 watts. Thermal resistance (junction to case) is 8.75 C/w. The device has been subjected to 1,000 hours storage at 200°C and tested for moisture and thermal shock resistance in cycles from —55° to 200°C.



Circle No. 156 on Subscriber Service Card

Subcarrier Discriminator

A transistorized subcarrier discriminator, employing the pulse-averaging method of FM detection, has been developed by Norden Div. of United Aircraft Corp.

The Model GD-201 incorporates all circuitry except the output power amplifier on removable printed circuit boards. Characteristics include: input voltage range, 10mv to 10v without adjustment; frequency range, 300 cps to 300 kc; input impedance, greater than 100 kilohms; linearity, 0.1% of best straight line. Gain control is continuously variable; output impedance is 0.1 ohm and power consumption is 7.5 watts.

Circle No. 157 on Subscriber Service Card

Test Table

A three-axis Scorsby test table, designed to simulate pitch, roll and yaw as an adjunct to environmental testing, has been developed by Tamar Electronics, Inc.'s American Wiancko Instrumentation Div.

The Model ST-1OA-1 has a table load capacity of 200 lbs. This allows an environmental test chamber, containing instrumentation, to be mounted on the table, eliminating the need to enclose the entire table in a chamber.

The angle of the table may be set almost instantly in 0.25-degree increments, from 0 to 7.5 degrees, to within 2 minutes of arc of the selected angle. For any of the table's angle settings, the combination of pitch, roll and yaw are equal to within 0.25 degree.

Circle No. 158 on Subscriber Service Card

Isolation Amplifier

An amplifier to provide isolation between a differential voltmeter and recorder is being produced by John Fluke Manufacturing Co., Inc.

The Model A88 makes it unnecessary to use recorders with high isolation and input resistance and eliminates possibility of voltmeter errors due to loading recorder output terminals. Input resistance is 950 ohms; input current is 0 to 2 μa. Other characteristics include a voltage gain of lv output per μa input and output impedance of 1,000 ohms. Maximum output is 2v open circuit. Input is isolated from the chassis by greater than 10^{11} ohms and can be floated up to 1,000v above ground.

Circle No. 159 on Subscriber Service Card

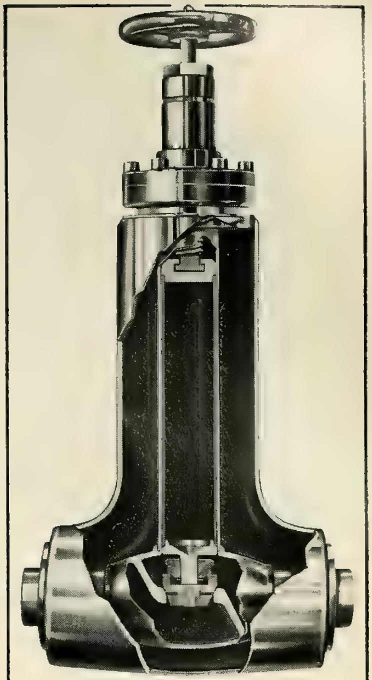
Inductance Bridge

Boonton Electronics Corp. has available a bridge which provides direct reading measurements of inductance over a range of 0.0002 microhenry to 110 millihenries.

The Model 63H also measures series resistance directly over a range of 0.0002 to 11,000 ohms. The device has a test signal continuously adjustable in frequency from 5 to 500 kc and, in level, from effectively 0 to 3v open circuit.

According to the firm, the unit's design is such that the test current through the specimen is unaffected by the balance condition of the bridge; once adjusted to a desired level, it remains constant as the null is sought.

Circle No. 160 on Subscriber Service Card



It solved our cryogenic fluid handling problem... We think it will solve yours, too.

Question: What do you do when you can't find a commercially available valve to meet your exacting requirements for cryogenic transfer line systems? Answer: Design your own. This is just what our engineers did, the result: a new series of jacketed and unjacketed valves for low loss handling of cryogenic fluids in five sizes from ½″ to 2″. Here are just a few of their features that we think will help solve your problems: high flow . . . low cool-down losses . . . low heat leak . . . bubble-tight shut-off . . . zero stem leakage . . . ease of operation and, most important, reliability. What's more the Series V-1060 Valves are available in three modes of operation—Manual, Cylinder and Positioner. Why not get the facts, write for our Bulletin 206.

cvi®
CryoVac
INCORPORATED
COLUMBUS 12, OHIO

Circle No. 13 on Subscriber Service Card

YOUR INVESTMENT IS SECURE IN TAX-FREE BAHAMAS!

The advantages are many... NO RESTRICTIONS ON PERMANENT RESIDENCE ON YOUR OWN LAND ... NO LAND TAXES ... NO BAHAMAS INHERITANCE TAXES ... NO CLOSING COSTS ... FREE DEED ... FREE TITLE INSURANCE. Land is a stable commodity—a sound investment—in this safe, secure, fast-growing area — not subject to wide fluctuations in economy or stock market. Right now we are offering a limited number of choice homesites on beautiful Grand Bahama, the fastest-growing island in the Bahamas, just 50 miles (80.5 km) across the Gulfstream from Florida, U.S.A. Become part of the social and community life on Grand Bahama where there are churches, schools, medical, dental, hospital services, stores, cinemas, businesses and booming industrial Freeport. Three 500-room hotels, and more are under construction ... luxury apartment blocks ... two championship golf courses ... marinas ... casino ... world-famous fishing and skin diving ... over 20 scheduled flights daily from Florida, plus steamer service.

Choose your homesites NOW—adjacent to all of this growth on Grand Bahama Island!

HOMESITES: *From $75 down—$75 on closing (within 90 days) balance from $15 monthly on mortgage note.

*Will accept any currency at its official bank conversion rate

AIR MAIL COUPON NOW!

SUNSHINE REALTY
777 Metropolitan Miami Building
Dept. MR-6, Miami, Fla 33132
PLEASE SEND FULL INFORMATION

Name____________________

Address____________________

City____________________

State__________Zip Code__________

Circle No. 14 on Subscriber Service Card

Sintered Metal Filters

Panoramic Corp.'s Sintered Specialties Div. has developed a means to consistently produce tough high-quality porous components from high temperature metals, the firm says.

In the filtration field, these discs and shapes filter from 2 micron minimum and are manufactured to specific flow rates and pressure drops associated with the viscosity of the fluid being filtered. Special non-spherical shaped powders are used to present the most tortuous path to the fluid being filtered, the company explained.

Filters are produced in various grades of stainless steel, monel 400 Hastelloy C and F, nickel, platinum and other high temperature metals. Sizes normally range from 1/16-in.-minimum thickness. Cleaning can be accomplished by backflushing, burning or utilizing solvents and acids.

Circle No. 161 on Subscriber Service Card

Portable Megohmmeter

A self-calibrating megohmmeter, the Model TR-10, has been developed by Consolidated Airborne Systems, Inc.

The unit is designed to eliminate shock hazard to the user by a maximum open circuit potential of 35v. Explosion hazard when working with fuel/air mixtures is eliminated by a maximum short circuit current of 33 microamps at nominal 33-v operation. The device has a range selectable over four scales: 0 to 10 megohms; 0 to 100 megohms; 0 to 1,000 megohms and 0 to 10,000 megohms. Accuracy is within 5% of reading. Input is 115v, 400 cps or 115v, 60 cps.

Circle No. 162 on Subscriber Service Card

Synched Framing Camera

A high-resolution camera that will record at rates from 250,000 to 20,300,000 pictures per second has been introduced by Beckman & Whitley, Inc.

The Model 189B was developed to meet needs of scientists studying lasers and laser effects, hypervelocity impact, plasmas, shocks and detonation phenomena.

The camera is more than 2.5 times faster than any other rotating mirror camera, the firm maintains. It can record 120 pictures, each resolved to 32 lines per millimeter. Exposure times are as short as 50 nanoseconds. Optics are designed to eliminate blind time between frames, allowing the camera to record all of the event which occurs during the recording period.

The system has three interchangeable rotating mirrors and four interchangeable objective lenses for flexibility in speed, object distance and magnification.

For portable use, the entire system —camera, controls, light source, pulse units—is integrated in an instrument cart.

Circle No. 163 on Subscriber Service Card

Liquid Cold Trap

A liquid nitrogen cold trap and water baffle, the CowldTrap, is being marketed by C&T R&D. The unit is designed to eliminate creep and backstreaming of pump fluid and to provide cryogenic pumping to improve the vacuum in oil or mercury diffusion pump systems.

The device has theoretical conductance equal to the pumping speed of appropriate pumps. It is constructed of low-vapor-pressure 304 stainless steel, heliarc welded and lead-checked with a 10^{-10} cc/sec. sensitivity leak detector. Features include a drain that allows removal of water or liquid nitrogen for fast warm-up and an insulating jacket that makes it possible to present only cold surfaces to the main vacuum.

Circle No. 164 on Subscriber Service Card

Coordinate Recorder

A device designed to simplify recording the location of particle trackers in a nuclear photographic emulsion has been announced by International Telephone and Telegraph Corp.'s Industrial Products Div.

Developed by ITT's Bell Telephone Manufacturing Co. in Belgium, the device punches out in paper tape three figures that record the start of a particle track in terms of its location in the width, breadth and depth of the block of emulsion. A similar set of three digits records the other end of the track.

Positioning screws and the focusing control are driven by electric motors equipped with electronic rotation recorders. An operator places the end of the track in focus, pushes a button and the three figures indicating location are punched in tape within two seconds.

Circle No. 165 on Subscriber Service Card

Rear-Window CRT

A 7-in. cathode ray tube with a 2-in. dia. rear window is available from Westinghouse Electronic Tube Div.

A radar image can be displayed on the flat face of the tube at the same time a photographic recording of the image is made through the optically flat rear window. A cascade screen is used in the Model WX-30027. As a result, blue light is emitted to the rear for photography and yellow light is emitted to the front for visual observation. The electron beam spot size is 10 mils. Maximum half-angle magnetic deflection of the CRT is 17 degrees.

Circle No. 166 on Subscriber Service Card

Current Leak Detector

A portable high-voltage dc test set for dielectric strength testing and insulation leakage determinations at test potentials from 0 to 15 kv is available from Associated Research, Inc.

The Model 5220 HYPOT^R will detect leakage currents as low as 0.05 microamps over four ranges: 0-2/0; 20/0; 200/0 and 2,000 microamps, full scale. A selenium rectifier power supply operates from 110 to 120v, 50-60 cps. Power supply provides up to 15 milliamps output current for charging of capacitance loads.

KILOVOLTS
MICROAMPS

Circle No. 167 on Subscriber Service Card

Component Oven

Glentronics, Inc., is marketing the Model HCC-0001E component oven for use in situations where parameter drift versus temperature might impair system performance.

The unit features a temperature stability of ±3°F (versus all external variables). Normal temperature is to 185°F; thermal resistance is 12°F per watt. Input voltage is 115v ac. (Units may be supplied to operate from dc voltages.) The usable internal cavity of the oven measures 1.44 x 2.00 x 3.31 in.

Circle No. 168 on Subscriber Service Card

SERIES 1600
WIDE RANGE RECEIVER
SCIENTIFIC-ATLANTA, INC., ATLANTA, GA., U.S.A.
FINE TUNING
AFC SERVO GAIN

WIDE RANGE RECEIVERS

FOR ANTENNA CHARACTERISTICS
REFLECTIVITY
SURVEILLANCE
RFI OR
QUALITY CONTROL MEASUREMENTS

This is Scientific-Atlanta's expanded family of Wide Range Receiving Systems:

For Antenna Pattern Ranges, the Series 1630/40.
- Frequency: 20 Mc to 100 Gc, without plug-ins.
- Sensitivity to —110 dbm.
- Linear dynamic range of 40 db, (60 db optional).
- Electronic and servo controlled AFC.
- Panoramic scope display of signal.

For determining characteristics of electromagnetic fields and general laboratory measurements of RF components, the Series 1650 Phase-Amplitude Receiver.
- Measures phase and amplitude 20 Mc to 40 Gc.
- Sensitivity to —95 dbm.
- Phase accuracy ±5°, including linearity, 40 db amplitude independence, and ½ hr stability.
- Phase range continuous 360° without limit.
- Recorder outputs from both channels.

For RFI measurements, laboratory application, and surveillance, the Series 1660 Scanning Receiver.
- Operates as a standard wide range receiver.
- Octave sweeping: 100 Mc to 16 Gc.
- Sweep rate: 5 sec to 60 sec.
- —60 db log output; analog frequency.
- Optional IF bandwidths.
- Preselection available.

For reflectivity and other measurements involving pulse transmission, the Series 1670 Receiving and Recording System.
- Frequency: 100 Mc to 60 Gc.
- Sensitivity to —85 dbm.
- PRF rates 500 pps to 55,000 pps.
- Input RF pulse widths 50 nsec to CW.

If these don't solve your problems, we can modify or develop to suit. Send us your requirements. We'll be happy to quote.

S·A

SCIENTIFIC-ATLANTA, INC.

Box 13654, Atlanta, Georgia 30324, Tel. 404-938-2930 TWX 404-938-1322 WUX Cable SCIATLA

Circle No. 15 on Subscriber Service Card

ADVANCED CAREER OPPORTUNITIES

VTOL

SYSTEMS ENGINEERING

The Research Analysis Corporation, a principal operations research and systems analysis advisor to the U. S. Army and other government agencies, has several excellent career opportunities available in advanced VTOL systems technology. Positions require 2 to 10 years' experience. Advanced degree desirable.

RAC's new research center in suburban Washington, D. C. offers you an unusual 'workshop for ideas' environment, plus the option of city, suburban or country living.

Aero. Engineer—Experience should include analysis of missile or aircraft weapons systems. Will perform systems engineering, systems analysis, advanced design, development of concepts and analysis of subsystem performance.

Aero. Engineer—Experience should include preliminary design of tactical aircraft systems (preferably V/STOL); propulsion systems specialty. Will perform systems engineering and design tradeoffs, development of concepts.

Aero. or Mech. Engineer—Experience should include preliminary design of aerospace weapons. Will perform systems engineering, systems analysis, development of concepts.

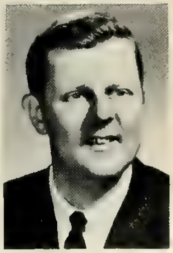
Remuneration is consistent with the importance of these positions. Please send your resume to: Mr. John G. Burke, Professional Staffing

RAC

RESEARCH ANALYSIS CORPORATION
McLean, Virginia 22101
(Suburb of Washington, D. C.)
An equal opportunity employer

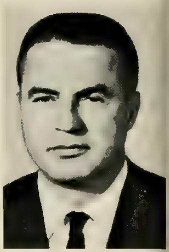
names in the news

FORD



DAHLEM

RAPAPORT



JOSEPHS

Dr. Ralph W. Tyler: Elected to the board of trustees of the System Development Corp. He is director of the Center for Advanced Study in the Behavorial Sciences in Stanford, Calif.

Raymond V. Ford: Elected vice president and treasurer of Maxson Electronics Corporation. He has been vice president-administration and finance at Maxson since 1963.

Dr. Felix Bloch: Became president of the American Physical Society on January 30. He is co-winner of the Nobel Prize in physics for 1952, and a professor of physics at Stanford University. **Dr. John Wheeler,** of Princeton University, became vice president at the same time. **Dr. Charles H. Townes,** provost of MIT and co-winner of the 1964 Nobel Prize for invention of the laser, became vice president-elect.

Dr. Richard Crane: Became president of the American Association of Physics Teachers on January 30. **Dr. Melba Phillips,** professor of physics at the University of Chicago became president-elect at the same time. She will succeed Dr. Crane in 1966.

William R. Merriam: Elected assistant vice president and director of Washington relations of International Telephone and Telegraph Corporation. He was formerly deputy director of Washington relations.

Thomas A. Saunders: Appointed as Washington, D.C., representative for Allis-Chalmers Research Division's Space and Defense Sciences Department.

Lance P. Johnson: Named manager of Hughes Aircraft Company's Microelectrictronics Div. at the firm's Newport Beach, Calif., facility. He will continue to serve as manager of the Electronic Products and the Industrial Systems divisions.

Sanford C. Sigoloff: Appointed to the newly established position of executive vice president of Electro-Optical Systems, Inc. He was formerly vice president and manager of corporate operations.

Richard K. Dahlem: Promoted to the new position of vice president of engineering and an officer of Semiconductor Specialists, Inc. He was formerly director of semiconductor circuit applications and engineering.

Lyman C. Josephs III: Joined Martin Company as director of aircraft development. He is one of the design patent holders on the F4U Crusader, the Navy's first supersonic carrier-based aircraft which won the Thompson and Collier trophies. He was formerly with Ling-Temco-Vought Inc.

C. A. Thomas: Elected chairman of the board and chief executive officer of Stratoflex, Inc., Fort Worth, Tex. **Cullen Davis** has been elected president of the organization to succeed Thomas.

Frank J. Kiernan: Named manager of the New York office of Aerojet-General Corp. He has been with Aerojet since 1958 and has experience and training in technologies which cover nuclear power to corrosion engineering.

Harold Rapaport: Joined General Instrument Corp. as group vice president of its Defense and Engineering Products Group. He was formerly executive vice president of ITT Kellogg Communications Systems and vice president of ITT Federal Laboratories.

J. Brian Shanahan: Promoted to director of materiel and contracts for Electronics Div. of Electronic Specialty Co.

Graham C. Turner: Named general manager of Westinghouse Electric Corporation's Computer Systems Div. He succeeds **Paul R. Sprowl,** who has been appointed to the headquarters engineering staff.

Hugh E. Webber: Joined Sanders Associates, Inc., as corporate director of research and techniques, a new position. He will be responsible for administering research, development and techniques programs.

Frank G. Hickey: Appointed group vice president for Capacitor and Allied Operations of General Instrument Corp. Before assuming this newly-created position, he was president of the Fairbanks-Morse Pump Div. of Colt Industries, Inc.

William R. Harter: Appointed director of research and development of Westrex Communications Div. of Litton Industries. He will direct the development of advanced radio, facsimile, digital data and audio communications products.

Advertiser's Index

ADDISON-WESLEY PUBLISHING CO., INC. 36
Agency—L. K. Frank Co.

AiRESEARCH MFG. CO., DIV.—THE GARRETT CORP. 33
Agency—J. Walter Thompson Co.

AMERICAN TELEPHONE & TELEGRAPH CO. 4
Agency—N. W. Ayer & Son, Inc.

BERYLLIUM CORP., THE 3
Agency—Harris D. McKinney, Inc.

BOEING CO., THE 14
Agency—Campbell-Ewald Co.

BURROUGHS CORP., DEFENSE AND SPACE SYSTEMS GROUP 22
Agency—Campbell-Ewald Co.

CALMEC MFG. CORP. 43
Agency—Schaeper Industrial Adv.

CRYOVAC, INC. 49
Agency—The Jay H. Maish Co.

DORSEY TRAILERS, SPECIAL PRODUCTS DIV. 39
Agency—Timbes & Yeager, Inc.

DOUGLAS AIRCRAFT CO., INC. 44
Agency—J. Walter Thompson Co.

E. I. DU PONT DE NEMOURS & CO., INC., FREON PRODUCTS DIV. 31
Agency—Batten, Barton, Durstine & Osborn, Inc.

EX-CELL-O CORP., FLIGHT & SPACE DIV. 2
Agency—LaRue & Cleveland, Inc.

GRAND BAHAMA PROPERTIES, LTD. 50
Agency—Arthur R. Mogge, Inc.

GRUMMAN AIRCRAFT ENGINEERING CORP. 47
Agency—Newmark, Posner & Mitchell, Inc.

HEXCEL PRODUCTS, INC. 12
Agency—Lennen & Newell

HUGHES AIRCRAFT CO. 6, 7, 41
Agency—Foote, Cone & Belding

LINK ORDNANCE DIV., GENERAL PRECISION, INC. 53
Agency—Hal Lawrence, Inc.

LOCKHEED MISSILES & SPACE CO. 8
Agency—Hal Stebbins, Inc.

LOCKHEED PROPULSION CO., DIV. OF LOCKHEED AIRCRAFT CORP. 28, 29
Agency—Hal Stebbins, Inc.

MINNESOTA MINING & MFG. CO., PHOTOGRAPHIC EQUIPMENT & OPTICS DIV. 13
Agency—Wolff Associates, Inc.

NATIONAL AIRLINES, INC. 48
Agency—Kenyon & Eckhardt, Inc.

RESEARCH ANALYSIS CORP. 52
Agency—S. G. Stackig, Inc.

RUST-OLEUM CORP. 46
Agency—D'Arcy Adv. Co.

SCIENTIFIC-ATLANTA, INC. 51
Agency—Bohm-King Associates

SPACE & INFORMATION SYSTEMS DIV. OF NORTH AMERICAN AVIATION, INC. 42
Agency—Batten, Barton, Durstine & Osborn, Inc.

SPERRY UTAH CO., DIV. OF SPERRY RAND CORP. 56
Agency—Reach, McClinton & Co., Inc.

THIOKOL CHEMICAL CORP., AEROSPACE DIV. 11
Agency—MacManus, John & Adams, Inc.

UNIVAC, DIV. OF SPERRY RAND CORP. 55
Agency—Daniel & Charles, Inc.

—when and where—

FEBRUARY

Flight Testing Conference, sponsored by the AIAA and NASA, Huntsville, Ala., Feb. 15-17.

Third Annual Conference of the Electronic Sales-Marketing Association, Summit Hotel, New York City, Feb. 15-17.

1965 Electrical and Electronic Trade Show, sponsored by the Electrical Representatives Club and the Electronic Representatives Assn., Denver Auditorium Arena, Denver, Feb. 15-17.

Fourth Annual Photo-optical Workshop and Product Display, sponsored by the Society of Photo-optical Instrumentation Engineers, Statler Hilton Hotel, New York City, Feb. 17.

International Solid State Circuits Conference, sponsored by the University of Pennsylvania and IEEE, Sheraton Hotel, Philadelphia, Feb. 17-19.

Annual Meeting of the United States Naval Institute, U.S. Naval Academy, Annapolis, Md., Feb. 18.

National Air Meeting of the Institute of Navigation, in conjunction with the Army, Navy and Air Force (classified confidential), State Department Auditorium, Washington, D.C., Feb. 18-19.

Sixth Annual West Coast Reliability Symposium, sponsored by the American Society for Quality Control and UCLA Engineering Dept., UCLA Campus—Moore Hall, Los Angeles, Feb. 20.

1965 Western Metal and Tool Exposition and Conference, sponsored by the American Society for Metals and the American Society of Tool and Manufacturing Engineers, Great Western Exhibit Center and Biltmore Hotel, Los Angeles, Feb. 24-26.

Annual Meeting of the Aerospace Systems Safety Society, International Hotel, Los Angeles, Feb. 24-26.

Fifth National Symposium of the Society for Information Display, Miramar Hotel, Santa Monica, Calif., Feb. 25-26.

MARCH

Twenty-first Annual Technical Conference of the Society of Plastics Engineers, Statler-Hilton Hotel, Boston, March 1-5.

Symposium on High Speed Testing, sponsored by Massachusetts Institute of Technology and Brooklyn Polytechnic Institute, Sheraton Plaza Hotel, Boston, March 8-9.

West Coast Symposium on Arms Control, sponsored by the American Ordnance Assn. and TRW Space Technology Laboratories, Los Angeles, March 9-10.

Aviation and Space Conference, sponsored by the American Society of Mechanical Engineers, Statler-Hilton Hotel, Los Angeles, March 16-18.

Sales

WANTED AN EXPLOSIVE SALES/ENGINEER

We need a man who:

- is experienced in the sale of conventional, EBW, and state of the art explosive ordnance devices.
- is currently selling to DOD agencies or its prime contractors.
- is interested in advancement in an expanding operation.

It is likely this man:

- has a degree in one of the sciences.
- is free to travel.
- has ambition and a strong desire to sell.

The Link Ordnance Division of GPI will develop the products . . .
we need a salesman to develop the customers.

Please contact in confidence, T. P. MacDougal, Phone (408) 736-9290

LINK ORDNANCE DIVISION
General Precision Inc.
670 Arques Avenue
Sunnyvale, California

An Equal Opportunity Employer

let us move with you!

Six Weeks Is Required To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, **if possible, the address label from your last issue . . .** include your postal zone or zip number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

Cost Reduction

WE KNEW FROM THE BEGINNING that the affair had had its start in San Diego—and that it had resulted in the single greatest cost reduction in the Secretary's economy program.

It has taken many months of hard digging to unearth just what transpired between these two events. Now, however, we are able to report exclusively how the Administration was able to hold the defense budget below $49 billion, thereby making it possible for the President to meet his declared goal of a national budget of less than $100 billion.

The whole affair began when a national car rental agency started giving away trading stamps—but it did not become a problem until Chuck X, employee of a San Diego aerospace firm, attempted to turn these in to the company with his expense account.

The stamps were returned to him with an interoffice memo from the Comptroller: "What the blankety-blank am I supposed to do with Green Stamps?"

He tacked the stamps up on his office pegboard, gazing thoughtfully at them from time to time as the weeks passed and adding to them each time he rented a car.

Six weeks after his initial attempt to turn in the stamps, Chuck had an idea. If the stamps were in government hands, they no longer would be his problem. He took them home, gave them to his wife and told her to give them to the wife of the Admiral who lived next door.

Two days later, the stamps came directly to Chuck in the morning mail with a stern note from the Admiral advising him that under the new Dept. of Defense Standards of Conduct Directive, the stamps must be regarded as a gratuity from the company and could not be accepted.

"Furthermore," the Admiral added, "it is my duty to report this attempted bribery by the company through the proper channels to my duly appointed representative within 48 hours."

The Admiral's Gratuity Acceptance/Rejection and Attempted Bribery Report DOD Form 708-13 went to the Commanding Officer of the Station, who passed it to the Commandant of the Naval District, who sent it to the Chief of Naval Operations, who gave it to an Undersecretary of the Navy, who gave it to the Secretary of the Navy, who handed it to the Secretary of Defense at a top-level meeting on Viet Nam.

Three days later, a representative from the General Accounting Office called on the company Comptroller.

"What," he demanded, "are you doing with your Green Stamps?"

"Green Stamps?" said the Comptroller nervously.

"Green Stamps," said the GAO man firmly. "Trading stamps rebated to company employees who obtain them while engaged on company business covered by government contract are the property of the United States Government. They must be delivered to the Government."

The subsequent GAO investigation occupied 87 men for eleven months and the findings are being summarized in a 220-page report, which is expected to be completed in the early spring of next year. Meanwhile, however, the San Diego firm took immediate steps to close the Green Stamp Gap, as it was called in the official inter-office memo and on the signs posted around the plant.

"I knew it," Chuck said. He took the stamps down off the board and put them in the mail envelope. His fellow employees did likewise, and the following week the Comptroller's secretary moved into the hall to make room for the Green Stamps. The week following that, the Comptroller moved into the hall. Our best count shows that at the height of the Green Tide, as the San Diego newspapers called it, 17 executives were operating from the hallway.

The tide began to recede after the company President, attending a meeting of the Board of Governors of the Aerospace Industries Assn. in Tucson, Ariz., mentioned the problem to another company President. Before the day was out, it was on the agenda of the Standardized Industry Practices Subcommittee, which moved that an approach be made to NSIA and Electronic Industries Assn. for a joint effort to solve the problem at the Pentagon level. Out of that meeting with DOD officials came the decision that the stamps would be turned in to contract representatives at the plants (or in the case of the Philadelphia area, to the centralized Project 60 office) for forwarding to the Defense Supply Agency.

Soon, carloads of Green Stamps were moving eastward from defense plants all across the nation. DSA stored them in warehouses made available by the sale of surplus Revolutionary War beltbuckles and there they remained until their presence was discovered on a inventory list by a junior member of the office of the DOD Comptroller.

OUR REPORTERS HAVE BEEN UNABLE to determine just who crossed the threshold of the Secretary's office first in the race to tell him of the discovery, but it is generally acknowledged in the Pentagon that it was the Secretary himself who conceived the brilliant idea of buying the *Poseidon* missile system with Green Stamps.

The San Diego aerospace firm, however, was the first to discover that financial crediting of the Green Stamp rebates put the cost-plus-incentive contract for its new booster right up against the profit peg, assuring a return of some 9% on the contract.

A few facts remain to be uncovered and the GAO report is awaited with some interest, but we now can state without fear of contradiction that that is how the Administration was able to hold the budget below $100 billion and it also is the factor behind the resurgence of confidence in aeropsace stocks on Wall Street.

What is your company doing with its Green Stamps?

William J. Coughlin

Circle No. 19 on Subscriber Service Card ⟶

Shhhhhhh!

They're testing at the Pacific Missile Range.

Once operational, PMR will have the world's largest Real-Time Data Handling System. Missiles and satellites will be thrust across thousands of miles of green ocean.

Guiding, controlling and tracking them will be a host of computers: land based, van mounted and shipboard computers.

UNIVAC® computers.

Backing it all up—UNIVAC experience. Data Systems experience—gained by the mating of these computers with a variety of precision tracking equipment—similar to the systems now in service on the Atlantic Missile Range.

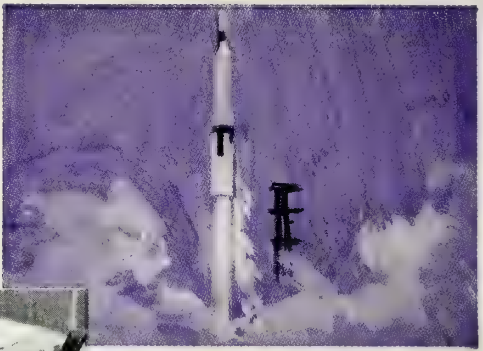
For maximum flexibility, ruggedized UNIVAC central and remote computers can operate individually or as a complete system. And each is built to very precise specifications. Military specifications. The toughest kind.

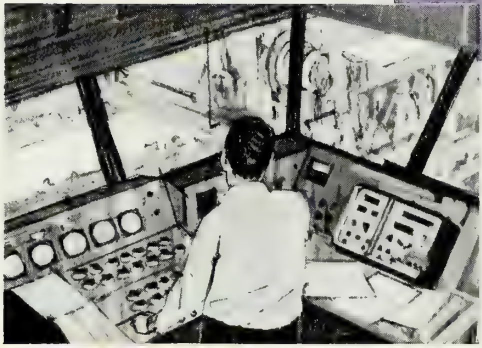
SHHHHHHH!

There's the countdown.

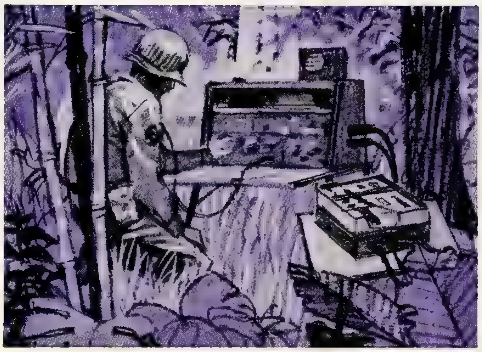
UNIVAC®
THE FIRST COMPUTER

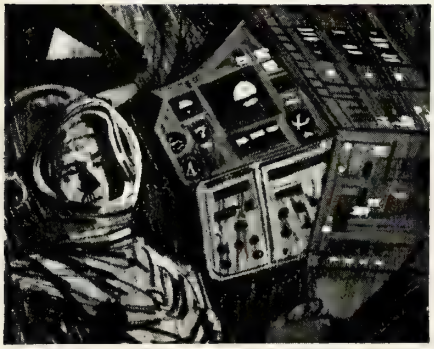
UNIVAC DIVISION OF SPERRY RAND CORPORATION





10 9 8 7 6 5 4 3 2 1





CCCS compresses time. The new Sperry Central Control Computer System provides for more efficient use of *time* in missile launches, space flight tests, communications and industrial process control. For example, it makes possible a "permitted" countdown for missile firings and support systems checkout. Each step of these highly automated operations begins immediately upon completion of the previous step. The countdown thus proceeds in the shortest *time* that equipment condition and mission will allow. Reliability, maintainability and repairability are designed into the CCCS—using plug-in electronic assemblies, fault isolation to sub-sub-sub-assemblies, and other advanced techniques—again with the emphasis on optimum timing. CCCS is field tested and available now. **SPERRY UTAH COMPANY, Salt Lake City, Utah.**

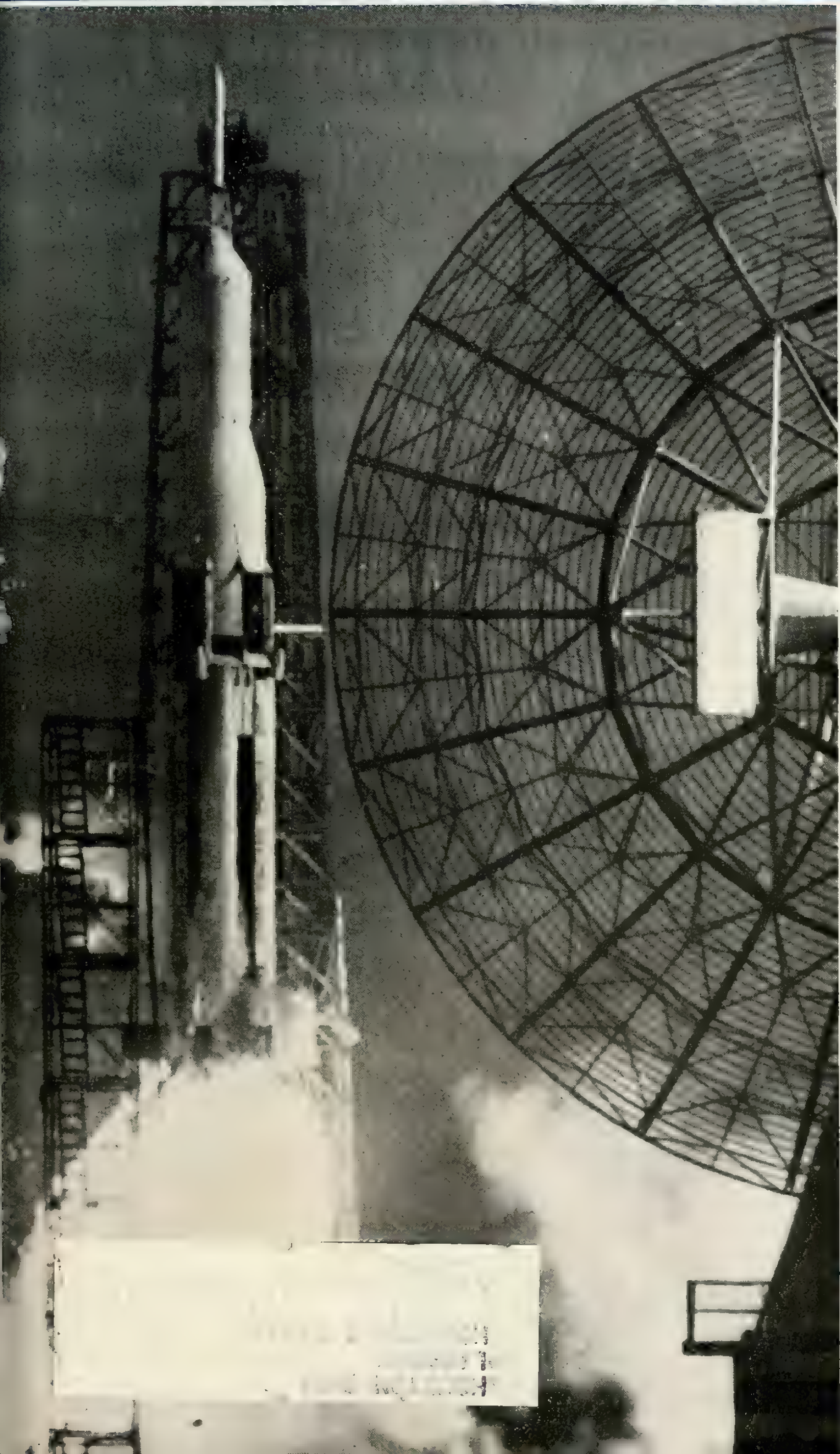
SPERRY
DIVISION OF
SPERRY RAND
CORPORATION

Circle No. 17 on Subscriber Service Card

FEBRUARY 22, 1965

missiles and rockets

HE WEEKLY OF ADVANCED TECHNOLOGY



McNamara Steps Up Air Defense System

Pegasus Follow-on Prospects Boosted

Standard Atlas Decision Nears

Controversy Over Mars Goals

Saturn SA-9 Lifts Off With Pegasus Satellite

AN AMERICAN AVIATION
PUBLICATION

0
2
6
ADVANCE
60
20

From ASI's continuing program of new product development

This computer offers more productivity per dollar than any in its class–the ASI 6020

Compare the computing systems offered in the low cost scientific and on-line systems range. Other computers offer some important features, but only the *ADVANCE* Series 6020 from ASI offers *all* of the features required to best satisfy your needs. Consider the complete instruction repertoire with rapid execution times such as—add 3.8 microseconds, double precision add 12 microseconds.

Three index registers and successive indirect addressing simplify programming operations. ☐ Multilevel interrupts are provided for control requirements—real time, data communication, etc. ☐ The Programmed Instructions feature allows special subroutines to be handled as hardware instructions. ☐ Input/output rate of 180,000 words per second per channel. ☐ A memory with a 1.9 microsecond cycle time which is directly addressable to 32,768 24-bit words. ☐ One pass FORTRAN II and one pass symbolic assembler allow for complete batch processing without operator intervention. ☐ Low purchase price of $73,500 for the central processor, $79,500 for basic system including typewriter, paper tape and buffered input/output channels. ☐ As is true with all computers in ASI's *ADVANCE* Series, the 6020 is packaged to offer a versatile and completely modular method of installing the system to meet your exact needs.

We would like to tell you more about the 6020 and ASI's Customer Support Program which helps you get the most out of your computers. In addition, you may wish information on the larger member of the *ADVANCE* Series, the high performance 6040 Computer. Contact an ASI representative today.

ASI

ADVANCED SCIENTIFIC INSTRUMENTS
DIVISION OF ELECTRO-MECHANICAL RESEARCH, INC.
8001 Bloomington Freeway, Minneapolis, Minnesota 55420

Circle No. 1 on Subscriber Service Card

S-IC Static Test Stand

Some test operations

New Orleans French Quarter landmark

Championship golf course adjacent to Pass Christian

Deep Sea Diving off the Gulf Coast

One of a hundred Bay Saint Louis fishing piers

have all the luck.

Ask any one of the 12,000 men and their families who make up the Gulf Coast aerospace community.

They all made the move. New Yorkers, San Franciscans, men and their wives and children from all over the country. Families who preferred quiet living in a suburban community and families who were used to life in a nerve center. They all came because of the excellent job opportunities which sprang up with this new aerospace industrial community between Gulfport and New Orleans. And they were pleasantly surprised at the excellent living in the area. They discovered that the only difference was not one of outlook, but of backdrop — magnolias and Spanish moss.

Take those who chose to live right on the water in any one of the famous Mississippi resort towns of Long Beach, Pass Christian and Bay Saint Louis. They're living a vacation all year round. Or those who settled in Slidell, Louisiana — a progressive, modern suburb to one of the most sophisticated cities in the U.S., New Orleans (less than an hour's drive from MTO). Then there are the families who make their homes in Picayune, Mississippi where home-town living in a small, friendly community appeals to their tastes.

Professionally they're contributing to some of the foremost space age activities in the country. The *Mississippi Test Operation*, under the aegis of NASA, is the new captive test site for the world's most powerful booster, the Saturn V — *and its successors*. General Electric is the prime support contractor for NASA at MTO and will operate and supply both the technical and plant support for all propellants and gases, data reduction, data acquisition, electronic and instrumentation laboratory, central control, meteorology laboratory, acoustical laboratory, facilities engineering and utilities, and all logistics functions.

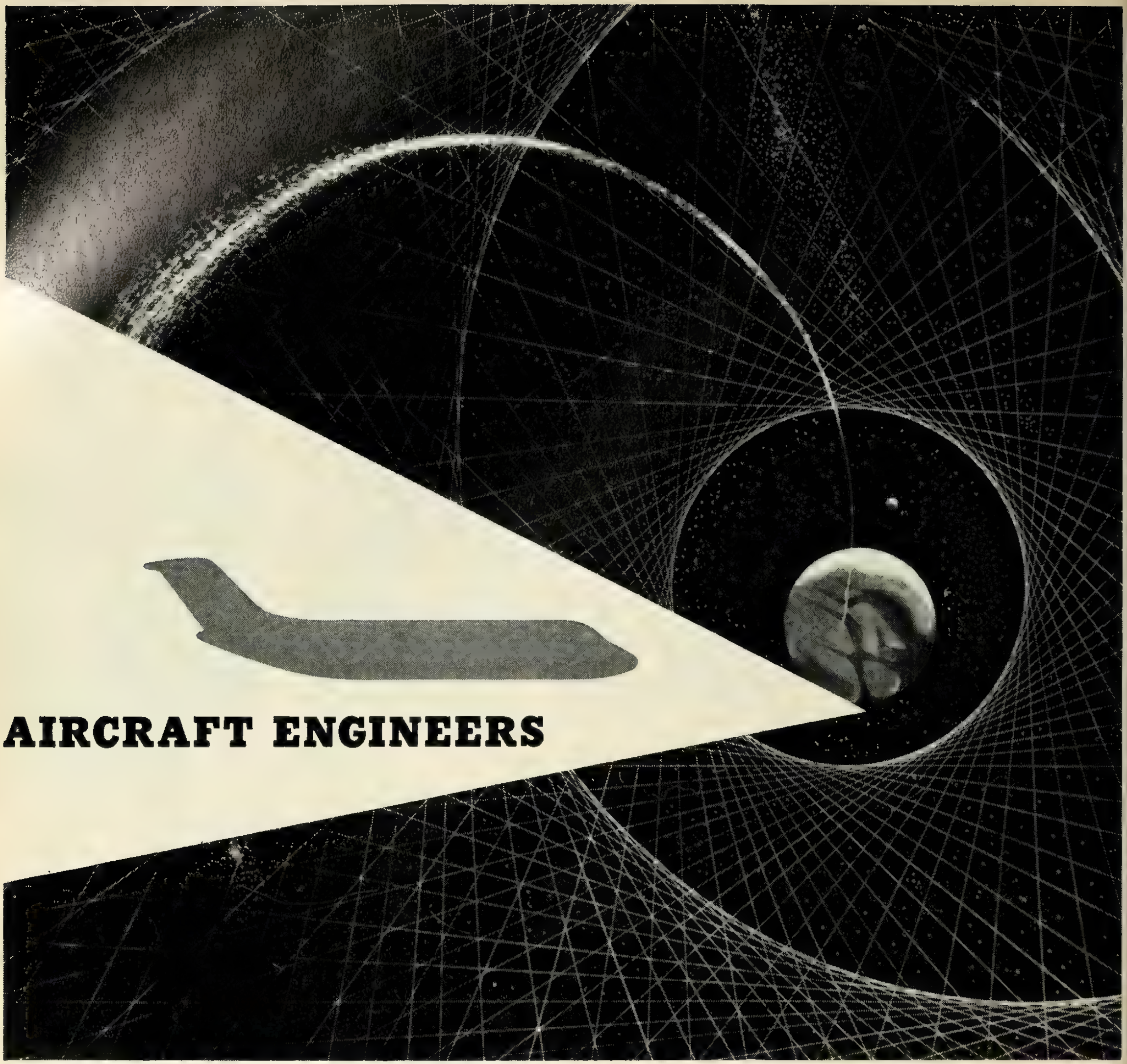
Professional opportunities now open: Engineers-Electronic/Communications (BSEE) ☐ Engineers-Control Systems (BSEE) ☐ Specialists-Data Reduction (BS Math, Physics or EE) ☐ Specialists-Computer Programming (College — 2 years minimum) ☐ Engineers-Instrumentation System (BSEE) ☐ Project Engineer-High Pressure Gas Facility (BSME) ☐ Project Engineer-Test Stand Cryogenic Systems (BSME) ☐ Project Engineers-Systems, Cryogenic Barges (BSME)

If you want to share in the "luck," check to see if your experience fits any of the openings; then write us: Mr. Frank F. Oppedisano, Professional Selection & Placement, General Electric Co., Mississippi Test Support Operation, Room 94-H, Bay Saint Louis, Miss.

Mississippi Test Support Operation
MISSILE & SPACE DIVISION

GENERAL ELECTRIC

An equal opportunity employer.



We have a ten year backlog of exciting programs... and more coming!

Our expanding schedule includes a huge program on what will be the largest aircraft ever built, the jet C-5A. It encompasses bigger, more advanced versions of the DC-8 and DC-8F; military and business configurations of the twin-jet DC-9; advanced versions of the Navy A-4E attack airplane and its two-place training counterpart, the TA-4E; and advanced aircraft. And there are other programs we can't publicize at this time.

Right now we are urgently seeking aircraft engineers with BS or advanced degrees who have experience in any of the following: Aerodynamics; Stress Analysis; Load Analysis; Dynamic Analysis; Electrical Design; Structures Design; Power Plant—Thermo-Mechanical; Flight Test Instrumentation; Flight Test Data Analysis; Reliability; Advanced Systems Engineering. Openings include a number of senior positions.

For full information, please send resume to Mr. C. D. Carrico, Professional Employment, Douglas Aircraft Company, 3855 Lakewood Boulevard, Long Beach, California. An equal opportunity employer.

DOUGLAS
AIRCRAFT GROUP

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 8 February 22, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors

Charles D. LaFond................Electronics
William S. Beller................Engineering

Associate Editors

Lawrence J. Curran......Assistant Managing Editor
Heather M. David..................Space Medicine
Michael Getler.........................Electronics
John F. Judge................Propulsion/Materials
Robert L. Parker......................Copy Editor
Rex Pay.............................Electronics
Hal Taylor.................................NASA
James Trainor............................Military
Donald L. Zylstra.........................Military

Contributing Editors

David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach.................Art Director
Donald Strickland............Assistant Art Director
Suzanne Montgomery............Editorial Assistant
Sally Fosnight...................Editorial Assistant

BUREAUS

LOS ANGELES.....9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks....................Bureau Chief
NEW YORK...................20 East 46th Street
Michael Getler
CAPE KENNEDY.................507 Orange Ave.
Merritt Is., Fla.
MIDWEST........................423 N. Quentin
John L. Zimmerman..................Wichita, Kan.
PARIS...........................11 Rue Condorcet
Jean-Marie Riche
GENEVA...........................10 Rue Grenus
Frank G. McGuire

EDITORIAL ADVISORY BOARD

Dr. Peter Castruccio **Alexander Satin**
Conrad H. Hoeppner **Vice Adm. H. Sanders (ret.)**
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton............National Sales Manager
Paul B. Kinney........Eastern Advertising Manager
Edwin J. Denker, Jr......Western Advertising Manager
Kenneth C. Blanchard.Marketing & Research Director
John N. Carlin..............Director of Circulation
Paddy Nelson................Circulation Promotion
R. Virgil Parker............Director of Production
Barbara Wiener........Advertising Services Manager

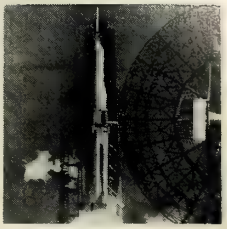
Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President.......................**Wayne W. Parrish**
Senior Vice President..............**Louis C. James**
Vice President......................**Fred S. Hunter**

THE COVER



Saturn SA-9 lifts off Feb. 17 from Cape Kennedy carrying Pegasus meteoroid detection satellite into near-Earth orbit. The launch was the eighth success in as many tries with the Saturn S-1 booster, and also marked the first time the vehicle was used to orbit a scientific satellite. See p. 14.

FEBRUARY 22 HEADLINES

NASA Said Able To Meet Possible DOD Saturn Needs .. 10
Methods for Uprating Saturn IB Considered 10
AT&T To Receive Comsat Corp. Research Contract 11
SA-9/Pegasus Flight May Spark Follow-on MDS Program . 14
Atlas Standard Launch Vehicle Decision Imminent 16
Breakdown of Space Agency's OSSA Budget Request ... 17
McNamara Statement Stresses Air Defense 18
Titan III-A Launch Described as Near-Perfect 21

NUCLEAR TECHNOLOGY

ARPA Array Enhances Underground Blast Detection ... 24

SPACE SUPPORT

Wider Use of Nondestructive Testing Advocated 27

SPACE MEDICINE

Biosatellite Life Support System Nears Completion 34

SPACE EXPLORATION

Mars Mission Aims Become Center of Controversy 39

DEPARTMENTS

Letters 6
The Countdown 9
The Missile/Space Week® 10
Technical Countdown ... 23
The Industry Week 43
Contracts 44
Products & Processes ... 48
Names in the News ... 52
When & Where 53
Editorial 54

49,100 copies this issue

Fats Scrud is a system.

Fats is a one-man band. He does not work for Hydro-Aire. Fats has a marvelous time with banjos and guitars and drums and things like that. In a manner of speaking, he is a system personified, a sort of musical series of components. His ability to coordinate these components into a heart-rending "Sweet Adeline" is an art in itself; but so is the more basic mastery of each individual instrument. ❀ Hydro-Aire does not make music. It does make valves, actuators, pumps, motors, filters, electronic control circuits, solid-state devices and a vast repertoire of other components. It understands hydraulics, electronics, pneumatics, electromechanics and fuel systems. And in this combination of systems knowledge with components experience there's a very happy tune for the aerospace industry. Examples: electro-hydraulic control systems, temperature control and coolant systems, even complete fuel management systems. Outstanding example: Hytrol Mark II, the world's leading automatic braking system for jet aircraft. ❀ It combines advanced servo-hydraulics with solid-state electronics. This system and its electro-mechanical predecessor are standard equipment on more than 11,000 aircraft. ❀ More recently, we've been developing liquid coolant pump assemblies for environmental control and life support on space satellites. And we've built a new air vane hydraulic servo control system for an ordnance type missile. It includes a hydraulic piston type pump, fluid filters, relief valves, de-pressurizing valves, servo valves, dual piston actuators and accumulators. ❀ One of these days we may even use all this know-how to figure out something to make life easier for old Fats Scrud. Meantime, we'll be appearing regularly in this space to fill you in on certain details. If you can't wait to get the big picture, we've got about 5,000 copies of a brochure that describes Hydro-Aire in detail. They cost a lot of money. Please send for one. On your company letterhead. Ready? All together now!

HYDRO-AIRE DIVISION OF CRANE
3000 Winona Avenue, Burbank, California

Circle No. 11 on Subscriber Service Card

letters

Fluidics Literature

To the Editor:

As a footnote to your impressively comprehensive issue on fluidics (M/R, Feb. 8), you may wish to report to your readers that NASA has, as of this writing, issued four separate scientific and technical reports in this field:

NASA CR-101 Fluid Amplifier State of the Art, Vol. 1, Research and Development on Fluid Amplifiers and Logic; $4.00.

NASA CR-102 Fluid Amplifier State of the Art, Vol. 2, Bibliography; $2.75.

NASA CR-137 Fluid Amplifier Application Studies; $3.00.

NASA CR-147 Fluid Amplifier Symbols, Nomenclature and Specification; $2.00.

These reports are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151, at the prices listed.

Melvin S. Day
Director, Scientific
and Technical Information Div.
National Aeronautics
and Space Administration
Washington, D.C.

Controlling EMC

To the Editor:

I am again urged to call your attention to the growing field of electromagnetic compatibility—this time as a result of your Jan. 18 editorial ("The Merry-Go-Round").

Your surmise that R&D is headed towards a critical period is only too true. However, the increasing problems connected with electromagnetic compatibility may help to fill this void.

The United States will soon have to face up, as a nation, to controlling its electromagnetic environment, as the military has had to do, if civilian electronic equipments are going to work in the future. As Rear Adm. Joseph E. Rice stated in his keynote address at the Tenth Tri-Service Conference on Electromagnetic Compatibility, in Chicago this past November, "EMC has sneaked up on the military and now it is sneaking up on the nation—EMC is the enemy of the electronic age. If we cannot control the enemy, we cannot control the electronic age."

You probably are familiar with the survey now being made by the Joint Technical Advisory Committee of the IEEE and EIA in response to a request by the Telecommunications Advisor to the White House. The results of this survey probably will turn up so many avenues necessary to control electromagnetic energy, throughout the spectrum, that it will make many of our past research projects look trivial. The sooner the civilian interests in the United States take Adm. Rice's statements seriously, the sooner the need for further R&D work will become apparent.

Rexford Daniels, President
Interference Consultants, Inc.
Boston

Circle No. 2 on Subscriber Service Ca

e can give you high temperature, high reliability

APPHIRE-TO-METAL WINDOWS

. . off the shelf!

phire-to-metal windows manufactured by Ceramics International
t the most exacting requirements of military and aerospace
lications. The techniques developed at CI produce a sapphire
dow with unsurpassed flatness and clarity, and rugged enough
vithstand the most severe environmental conditions. At CI we
producing, faster and cheaper, sapphire-to-metal windows of
erior quality for the broadest range of standard and special
lications.

seal is guaranteed to leak less than 10^{-10} std. cc/helium/sec.
our parts are hydrogen brazed with OHFC copper, fine silver or
solder—72% Ag. 28% Cu Eutetic.

Applications include:

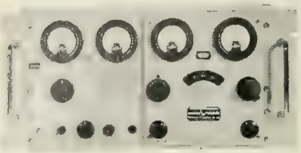
- **Detector windows for military infrared guided equipment.**
- **Optical windows in high pressure or high temperature systems.**
- **Satellite thermionic converters for converting sunlight directly to electricity.**
- **Windows for transmission of ultraviolet and X-rays.**
- **Output windows for microwave tubes such as klystrons or magnetrons.**
- **Internal supports for vacuum tubes, insulators, and low leakage detectors.**

We also make ruby-to-metal seals to the standards required for laser application.

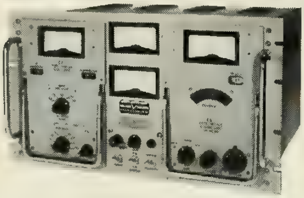
For further details write for our new bulletin #S110.

CERAMICS INTERNATIONAL CORP.
MAHWAH, NEW JERSEY

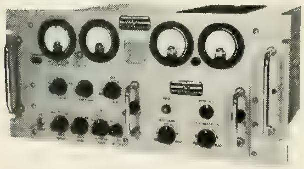
HIGH TEMPERATURE CERAMIC-TO-METAL PRODUCTS FOR THE AEROSPACE AND ELECTRONICS INDUSTRIES



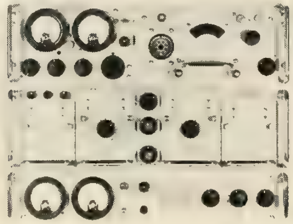
- **TMR-2A:** 215 to 265 mc Tuning Range; VFO or XTAL controlled.
FM or PM.
FM demodulators—Wideband, Narrowband, Phase lock.
Phase Demodulators—Short loop.
Pre-D: Plug-in record and playback modules.



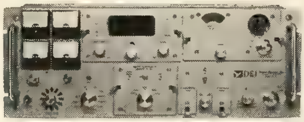
- **TMR-5A:** 55 to 2400 mc; Tuning Units VFO or XTAL controlled.
AM/FM, PM.
FM Demodulators—Wideband, Narrowband, Phase lock.
Phase Demodulators—Short loop.



- **TMR-6:** 50 to 1000 mc; Fixed Frequency XTAL controlled
RF Tuning Units. AM, FM or PM.
FM Demodulators—Wideband, Narrowband, Phase lock.
Phase Demodulators—Long loop.
Pre-D: Plug-in record modules.



- **TR-101:** 100 to 2400 mc; Tuning Units VFO, XTAL controlled
and Automatic Phase Control. AM, FM or PM.
Dual Data Channels.
FM Demodulators—Wideband, Intermediate, Narrowband.
Phase Demodulators—Long loop, Short loop.



- **TR-711:** 100 to 2300 mc; Tuning Units VFO, XTAL controlled
and Automatic Phase Control. AM, FM or PM.
FM Demodulators—Wideband, Intermediate band, Narrowband.
Phase Demodulators—Long loop, Short loop.
Plug-in display unit or Pre-D record and playback modules,
or oscilloscope.
- These receivers are compatible with TDC and DC series Diversity Combiners and the PRU-1 and PD-101 Predetection Record/Playback units. Plug-in IF bandwidth determining modules and plug-in demodulators are used in these receivers.

Other options are described in individual receiver data sheets.

DEI TELEMETRY RECEIVERS...

Technically Superior
Reliable by design
Modular for flexibility
Available now

Telemetry receivers are very important at DEI. Development and planning never stop. We consider new requirements, new components and the constant need to advance telemetry system performance. It is a rare telemetry receiving function that cannot be met by a DEI catalog receiver/module combination.

DEI receivers that have been in use for many years are updated by module changes to achieve new system characteristics. System modifications are introduced with minimum interruption when the DEI modular approach is used.

For your telemetry applications, consult DEI, the company where receivers and receiving systems are constantly being improved.

Write or call DEI for your copy of detailed specification sheets.

DEI
RESEARCH
DEVELOPMENT
MANUFACTURING

Defense Electronics, Inc.
Rockville, Maryland

ROCKVILLE, MD. (301) 762-5700, TWX: 302-427-4660; **SHERMAN OAKS, CALIF.** (213) 872-2870, TWX: 213-783-2742; **COCOA, FLA.** (305) 632-5400, TWX: 305-632-5442; **WILLOW GROVE, PA.** (215) 659-5051; **INT'L.,** ROCKVILLE, MD.; **CABLE:** DEIUSA

Circle No. 3 on Subscriber Service Card

The Countdown

WASHINGTON

DOD Looks At Missile-Carrying B-111

Dept. of Defense is studying a strategic version of the F-111, identified as the B-111, which would carry the new *Short Range Attack Missile (SRAM)*. Total cost of *SRAM* development is estimated at between $100 and $150 million, including $5 million of FY '65 funds and $37 million of FY '66 funds.

Radar Phase-Out Is Planned

A study by North American Air Defense Command has identified six more search radars which can be phased out during the current fiscal year, four more in FY '66 and six more in FY '67. Eight gap-filler radars also are to be eliminated in FY '65.

Anti-Satellite Tracking Stations Set

First of two large ground based optical installations for satellite tracking and photography for Dept. of Defense will become operational shortly at Cloudcroft, N.M. A second system in Maui, Hawaii, also is under construction.

Mauler Decision Is Still Pending

Secretary of Defense McNamara, describing *Mauler* as a disappointment, says no further funds for the missile will be requested at this time. All presently available *Mauler* funds will be applied to other air defense programs. Final decision on *Mauler* development is being withheld while its problems and slippage are studied—but the future obviously is dark.

Pershing Procurement Nears an End

Army's Fiscal 1966 procurement of *Pershing* missiles will bring the inventory to 100% of its objective and also provide sufficient missiles for annual practice and tests.

No Decision Yet on Lance

No decision has been made on the deployment of the *Lance* missile as a lightweight replacement for *Honest John* and *Little John* in the Army inventory, according to Secretary McNamara. Further development effort is planned.

First Big Shillelagh Buy Is Set

Dept. of Defense budget for FY '66 includes $61 million for the first major procurement of *Shillelagh* missiles for use on the General Sheridan vehicle. An additional $4.7 million will be required to complete development and testing in this connection, and $3.5 million for further work on a new stabilized sight and range extension.

Redeye Procurement To Get Under Way

Dept. of Defense now is ready to initiate procurement of the *Redeye* missile for both Army and Marine Corps. For the Army, it is proposed to reprogram $21.8 million to start the production program, with an additional $58.3 million to continue in FY 1966. For the Marines, $10 million would be reprogramed, with an additional $8.7 million requested for FY '66.

DOD Will Cancel Bullpup B Buy

Navy is cancelling its proposed buy of the *Bullpup B* in FY '66 in view of substantial procurement planned of *Snakeye, Walleye* and *CBU-3* (a chemical-biological warfare weapon). Air Force also plans to use *Walleye,* will buy no more *Bullpup B's.*

Sparrow III Procurement To End This Year

Air Force and Navy will stop buying the *Sparrow III* air-to-air missile at the end of FY '64 funding. Excess Navy inventory has been transferred to bring Air Force up to its full requirement.

West Coast Launches for Titan III-X/Agena

Current plans for the *Titan III-X/Agena* program call only for West Coast launchings. Air Force reports that current *Titan II* facilities at the Eastern Test Range could be modified for the new booster. NASA, which will want to launch from Cape Kennedy if it decides to use the new booster, believes cost of ETR launch facilities will be prohibitive, however.

NASA Plans Hypersonic Facility

Next big step in hypersonic research will be construction of ground test facilities with an estimated cost of $30 to $70 million. Space agency officials hope to make a start on the project in FY '67 even though they doubt that a full-fledged aerospace plane will be available until the 1980's.

Next Centaur Set for Early March

Launch date for the *Centaur AC-5* flight is now tentatively set for March 2. It, like *AC-6,* will inject *Surveyor* dynamic models on 66-hour simulated Earth to Moon transfer orbits, but these models will not be aimed for the Moon.

SERT Effort to Evaluate Thrusters

NASA's FY '66 research effort in *Space Electric Rocket Test* (*SERT*) will be devoted to evaluation and development of advanced thrusters for satellite attitude control and the initiation of flight verification of a new *SERT III* system. Exact configuration will not be known until results of current testing of subsystems is completed.

NERVA Hot-Flow Tests Planned in FY '66

NASA now expects to complete cold-flow tests of the *NERVA* engine in the next fiscal year. Test hardware is also expected to be modified in order to check out the engine test stand in Nevada. Hot-flow engine tests will begin in the same fiscal period.

INTERNATIONAL

Soviets Fail to Cooperate

NASA officials appear increasingly vexed at the failure of the Soviets to cooperate in sending meteorological satellite data over the communications link set up by the Weather Bureau with its Moscow counterpart. Dr. Hugh Dryden said that the operation will be terminated if the agreement is not fulfilled "in a reasonable period." Conventional data has been exchanged since last October.

SURE
SHOT

New micro-miniature switch.

Available in single-pole model; multi-pole and sequencing varieties to come. Function time is less than 1 millisecond at 2 amps firing current.

It's one of a wide variety of Atlas explosive-actuated components and systems that offer infinitely greater reliability . . . in smaller space . . . with less weight . . . and with lower power requirements than any other type of electro-mechanical system. Think of this when you work on one-time performance systems.

Send for technical literature giving specifications and characteristics on a variety of Atlas explosive components — switches, actuators and specialty devices and systems.

ATLAS
CHEMICAL INDUSTRIES, INC.
Aerospace Components Division
Valley Forge, Pa. 19481

Circle No. 4 on Subscriber Service Card

The Missile/Space Week

Saturn Production Rate Grows

The space agency has made it clear that it could handle any possible Dept. of Defense needs for *Saturn IB* or *Saturn V* vehicles by 1969, by adding to existing production and test facilities.

By this date, NASA Associate Administrator Robert Seamans told the House Science and Astronautics Committee, NASA on its current schedule will be able to produce and launch up to six *Saturn IB* and six *Saturn V* vehicles per year. He added that additional procurement of *Apollo* systems beyond those already approved could be initiated in FY 1967.

Most of the *Apollo* and *Saturn* hardware for the manned lunar landing will be required in advance of FY 1969, he said, leaving a lull at the end of the decade.

With minimum modifications of the *Apollo* system, Seamans said, NASA could provide a wide range of intermediate mission options "extending well into the decade of the 1970's." These mission options, he said, include polar, inclined, equatorial and synchronous orbital manned flights of durations up to two months with scientific technological and human research goals.

Some of the missions known to be attractive to DOD were listed as possible with these systems. Seamans told the committee that extended maneuvering exercise may lead to in-orbit repair and vehicle-to-vehicle rescue or inspection capabilities.

The present studies within NASA and DOD, which will determine the fate of the Air Force *Manned Orbiting Laboratory* program, are purposely eliminating questions of management, NASA Administrator James E. Webb told MISSILES AND ROCKETS. After this study, which essentially is a technical survey, management questions will be worked out, possibly by the Aeronautics and Astronautics Coordinating Board, Deputy Administrator Dr. Hugh L. Dryden said.

Webb also said that he will discuss with the chairmen of the House and Senate space committees this week the question of how to present briefings on the SNAP 8, M-1, and 260-in. solid-propellant programs, all of which were deleted by the President from the FY 1966 budget.

Webb has emphasized this year in several instances he feels that the budget level of five and a quarter billion is "less than the optimum level of five and three-quarter billion, originally recommended by President Kennedy."

He has made it clear that he objects to the deletion of these three programs, saying that he feels the real problems now facing NASA are in improved propulsion systems and advanced on-board power systems.

Shots of the Week

The Eastern Test Range was a busy place last week, with three launches of more than routine importance from Cape Kennedy and one *Polaris A-3* firing from the nuclear submarine John C. Calhoun. A *Titan III-A* (see p. 21) performed as planned after a Feb. 11 launch. The shot was considered a major milestone on the road to operation of *Titan III-C*.

- *Saturn SA-9* (see p. 14) was successfully fired from the Cape on Feb. 16 carrying with it the *Pegasus* meteoroid detection satellite.
- *Ranger VIII* (see item, p. 12) was boosted from the Cape Feb. 17 aboard an *Atlas*.
- The crew of the Navy's USS John C. Calhoun, a new ship specially designed for firing the *Polaris A-3*, scored the 17th consecutive success for the *A-3* in a shot that had the additional distinction of being the 250th *Polaris* launch.
- At Fort Wingate, N.M., on Feb. 12 the Army made a successful launch of a *Pershing* tactical missile. The shot landed within its White Sands Missile Range Target area.
- Air Force Maj. Robert Rushworth on Feb. 17 flew the Air Force-NASA *X-15* rocket plane. All objectives of the flight were said to have been achieved, and Rushworth landed safely despite a prematurely deployed landing skid.

Saturn Uprating Considered

Four typical approaches to uprating the basic *Saturn IB* launch vehicle system have been described by a NASA official.

F. L. Williams, assistant to the director, Marshall Space Flight Center told the American Astronautical Society's Denver symposium on Unmanned Exploration of the Solar System that many different methods have been considered to provide both increased payloads and overall cost effectiveness.

As examples of the uprating schemes under consideration, Williams detailed the following:

—Uprating the S-1B stage engines by increasing the thrusts of the H-1 and J-2 powerplants to 225,000 lbs. and 215,000 lbs., respectively. This would add 1,000-2,000 lbs. net payload in a 100-mi. Earth orbit to the 37,000 lbs. now available with the current *Saturn IB*.

—Uprating the H-1 engine to 225,000 lbs. and replacing the J-2 with a high-pressure (3,000 psi) engine of 315,000 lbs. thrust and increasing the S-IVB propellant load to 350,000 lbs. This would add 3,000-4,000 lbs. to the basic net *Saturn IB* payload in Earth orbit.

—Adding four *Minuteman* solid motors (first stages) to the *Saturn* IB. This increases the payload in Earth orbit 7,000-10,000 lbs.

—Adding four 120-in. solid motors (stage zero), which would add some 43,000 lbs. to the basic payload ability of the *Saturn IB*.

The inclusion of a *Centaur* upper stage to each of these possible configurations substantially increases the net escape velocity payload ability of the *Saturn IB*.

RMD, STL Get C-1 Engine

Both TRW Space Technology Labs and Reaction Motors Div. of Thiokol Chemical will work up the program definition phase of the 100-lb.-thrust "Common" rocket engine under 6-month, fixed-price contracts totalling $1.5 million.

One contractor will probably be chosen to continue into the second or development phase after these concurrent programs are completed.

The C-1 engine program is a concept based on a single engine design to perform various functions such as spacecraft attitude control, maneuvering, and launch vehicle ullage and attitude control.

Delta Goes West

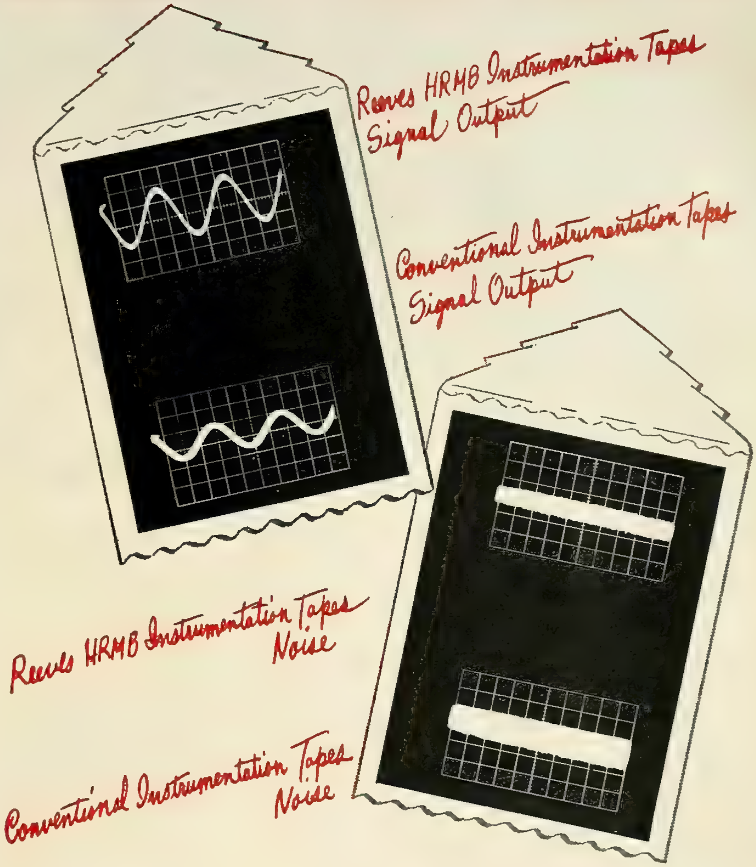
The Defense Dept. and NASA have announced an official agreement to establish launch facilities for the *Delta* booster at the Western Test Range. The two agencies will share costs of the launch facilities. Present Air Force *Thor-Able Star* installations will be adapted for *Delta* use when practicable.

Each agency will be responsible for its own missions. DOD has also agreed that when the improved *Delta* configuration—now being developed—proves its reliability, the *Thor-Able Star* booster will be phased out and replaced by the *Delta*.

AT&T To Get Comsat Pact

Communications Satellite Corp.

SEE WHY THE NEW
REEVES INSTRUMENTATION TAPES ARE THE
ONLY TAPES YOU CAN AFFORD TO USE?


Reeves HRMB Instrumentation Tapes
Signal Output
Conventional Instrumentation Tapes
Signal Output
Reeves HRMB Instrumentation Tapes
Noise
Conventional Instrumentation Tapes
Noise

This dramatic advance in performance is the result of Type HRMB's special oxide and binder system combined with MICRO-PLATE* — Reeves Soundcraft's exclusive new process which produces the smoothest surface in a tape today.

In addition to its better signal output and noise characteristics, Type HRMB offers these improvements over conventional instrumentation tapes:

• Lower distortion • Freedom from shedding (oxide and binder are locked together) • Lower head temperatures and less abrasiveness — assuring longer head and tape life • Higher electrostatic conductivity for uniform static drain.

Available in "A" oxide for normal bandwidth applications—"B" oxide for extended bandwidth applications. Write for new Reeves Soundcraft Instrumentation Tape brochure.

Polaroid photos are actual tests of tapes run on Sangamo Model No. 4742 recorder reproduce system.

*Reeves Soundcraft T.M.

DIVISION OF REEVES INDUSTRIES INC.
GREAT PASTURE ROAD, DANBURY, CONN.

New York • Chicago • Los Angeles • Export: C.B.S. International, 46 E. 52 St., N.Y.C. • Canadian Reps: Toronto

Circle No. 5 on Subscriber Service Card

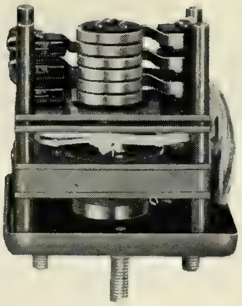
NOW
a programmer

that combines the best features of both spring and motor-driven timers

RAYMOND
ENGINEERING LABORATORY, INC.
MODEL
REV
ORD NO
SERIAL

The Raymond Model 1850 offers all of these advantages —

- **REPEATED TEST CYCLING** from a remote location
- **NO EXTERNAL POWER** after actuation
- **PROVEN DEPENDABILITY** of a mechanically driven timer
- **HIGH ACCURACY** in extreme environment
- **COMPACT**, light, rugged
- **FLEXIBILITY** for wide application
- **SEMI-MODULAR CONSTRUCTION**

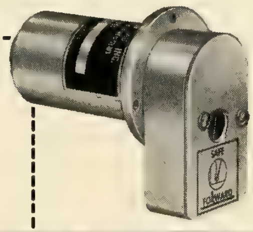


The Model 1850 is a mechanical timer driving one or more cam actuated switches, for timed switching in flight, with the added advantage of a remote start and rewind mechanism for preflight checkout. It gives you the **best of both** . . . electrical control for repeated preflight testing, from a remote location, and the assurance of the proven dependability of a spring-driven programmer in flight. Model 1850 is essentially a modularized version of a programmer already in use on several major aerospace programs, and consists of an electric start/rewind mechanism, a mechanical timer and up to 6 cam-operated switches. During preflight checks, the timer can be started from a remote location, and operation monitored. At the end of the complete time cycle, the timer rewinds and is ready for flight, or repeated testing. The rewind cycle requires 12 or 28 vdc for a maximum of 15 seconds; starting requires a 30 millisecond pulse. Standard time ranges are available from 0-15 seconds to 0-300 seconds; each switch can be individually set within this range. The flexibility of Model 1850 permits a variety of special features including time ranges up to 20 hours, switching for up to 30 circuits and electrical squib or "g" force actuation in flight. Literature or further operational details will be sent to you promptly upon request.

RAYMOND INTERVAL TIMER

The Model 1060 is the world's most proven precision interval timer. Modular design permits great versatility of application. The timer consists of three basic components — an actuator initiated by "g" force, pull wire, or squib dimple motor; a spring-driven timing mechanism; and a wide range of electrical switching combinations. Standard maximum time settings of 15, 30, 60, 90, 180, and 300 seconds. The unit provides reliable operation under the following environmental conditions; temperature, −65°F to +200°F; Humidity, 95% at 160°F; Sustained acceleration, 50 "g"; Shock, 100 "g" for 11 millisecond duration; Vibration, 15 cps to 2000 cps at 10 "g".

Write for comprehensive literature.



Raymond
CAPABILITY - RELIABILITY

RAYMOND ENGINEERING LABORATORY, INC., 1011 SMITH ST., MIDDLETOWN, CONNECTICUT

Circle No. 6 on Subscriber Service Card

is planning to award a $300,000 research contract to American Telephone & Telegraph Co. The work will be aimed at determining necessary technical parameters for proposed ground stations for the global communications system.

The contract also provides for consultant services, to be paid for on a cost-plus basis, if and when they are used. AT&T, one of six firms submitting proposals last November, will be restricted from providing hardware for the ground stations.

Meanwhile, three more nations signed the international agreements, bringing the total to 31. New signatories were China, Iraq and Ceylon.

WTR Now Under Air Force

The Air Force officially assumed operating responsibility for the Air Force Western Test Range (AFWTR) at Vandenberg AFB, Calif., on Feb. 1 in a move to take over the Point Arguello Missile Facility operations.

DOD scheduling calls for the transfer of all functions at Arguello from the Navy to the Air Force by July 1, 1965. Civil service positions and many of the top specialist billets were transferred to the Air Force from Navy rolls before the official assumption of operations by the Air Force.

The Navy decommissioned the Point Arguello facility July 1, 1964, when it became physically a part of adjacent Vandenberg AFB. The Navy continues to operate its Pacific Missile Range (PMR) and, pending development of AFWTR communications, continues to provide communications and data reduction services.

Ranger VIII Launched

The *Ranger VIII* spacecraft—launched successfully on Feb. 17—was slated to hard-land on the Moon early on Feb. 20.

Soon after the launch, the space agency announced that the spacecraft trajectory was well within the capability of its mid-course guidance correction motor. Without the guidance correction—scheduled for 5 a.m. EST on Feb. 18—*Ranger VIII* would have missed the trailing surface of the Moon by 1,136 mi.

Target of the picture-taking spacecraft is the Sea of Tranquility. Preliminary study of tracking data put the impact point roughly 20 to 30 degrees east and up to 15 degrees north of the Moon's equator. Impact time was expected to be early in the morning of Feb. 20, but a precise time could not be set until after the mid-course correction.

ELECTRONIC SURVIVAL
1000 to 250,000 G

16 inch gun at McGill University — U.S. Army project HARP launching site, Barbados.

1/4 watt, 250 Mc/s, 50,000 g transmitter successfully gun launched and operated to an altitude in excess of 300,000 feet.

The Aerophysics Division specializes in data transmission systems operating in the 50 to 250 Mc/s, 400 to 406 Mc/s and 1660 to 1850 Mc/s ranges for use in gun launched vehicles and other high acceleration applications.

Components capable of high g survival, such as event timers and inertia switches, are also available.

The experienced staff and extensive facilities of the Aerophysics Division are available to Government and industrial agencies.

Computing Devices
OF CANADA LIMITED
P.O. BOX 508 • OTTAWA 4 • CANADA
AN AFFILIATE OF THE BENDIX CORPORATION

C64.13

Circle No. 21 on Subscriber Service Card

Saturn batting 8 for 8 . . .

Hope Grows for Follow-on Pegasus

Space agency already asking funds for further study of possible cislunar probes to report on meteoroids; details of Feb. 16 success

by Michael Getler

CAPE KENNEDY—The successful flight of *Saturn SA-9* may have boosted NASA prospects for getting a follow-on *Pegasus* program to probe cislunar space.

If approved, two more *Pegasus*-type satellites would be orbited to report on meteoroid activities during extended flight in the vicinity of the Moon.

SA-9 lofted the first *Pegasus* into its intended near-Earth orbit Feb. 16.

Some NASA scientists have speculated that the level of meteoroid activity ranging from outwards of 100,000 miles from Earth to lunar distances, where most of a lunar mission's time will be spent, may actually be less than those levels believed to be present in the near-Earth environment. Should this be correct, spacecraft designers may be able to take advantage of reduced shielding requirements to increase life support systems and increase stay-times for future lunar orbit or lunar surface exploratory craft.

This means of investigating the meteoroid levels associated with the cislunar area for extended periods has been under study within NASA for more than a year. Part of the agency's line-item for *Pegasus* in the FY '66 budget request calls for funds for a new engineering study to evaluate existing spacecraft and boosters in order to define changes or modifications required by the cislunar mission.

Two NASA installations—Marshall Space Flight Center and Langley Research Center—will play an important part in the current study effort, if it is approved in the FY '66 request. Insiders say MSFC probably will assume the major role if existing *Pegasus* spacecraft can be modified to the cislunar mission, since MSFC is managing the current *Pegasus* effort, and that Langley might develop a larger role if extensive new designs are involved.

- **Telescoping possible**—About $1 million has been asked for the FY '66 study, which program sources told MISSILES AND ROCKETS would normally take about four to six months. However, they also say the apparently highly successful *SA-9* shot no doubt could shorten the study period, and that a request for reprogramming of FY '66 funds to allow a start on a follow-on satellite could come shortly after the study is completed.

The current three-satellite *Pegasus* program will cost about $30 million. A follow-on program probably would involve two satellites using the three-stage *Saturn IB/Centaur* combination, and might also cost about $30 million, depending upon the amount of new R&D and redesign.

Scientists associated with the program feel that satellites launched in 1968, while perhaps too late to gather all of the detailed long-term scientific data scientists would like to have in hand prior to the initial lunar-landing attempt, would be in time to supply valuable engineering data affecting more malleable aspects of spacecraft design.

Pace of the project would be determined in large measure by progress in the booster development effort. Some NASA scientists report that flight tests of the *Saturn IB/Centaur* could come by late 1967.

- **Just as planned**—Launching Feb. 16 of the 3,200-lb. *Pegasus* into an Earth orbit ranging between 458 and 308 statute miles, almost exactly within pre-launch predictions, marked the first time the *Saturn* has been used to place a scientific payload into space. *Pegasus* also is the largest unmanned instrumented satellite yet developed by NASA.

Space agency officials are optimistic about the solar-powered satellite's ability to provide continuing data on a wide range of meteoroid characteristics—direction, penetration capabilities, and short- or long-term frequency variations. The satellite is believed to have recorded its first meteoroid hit, on an 8-mil target panel during its fourth orbit, and scientists were expected to read out and analyze on-board recorded data to confirm this late last week. Desired lifetime of the satellite is one year. However, some project officials, noting that there are 55,000 parts aboard, are hesitant at this point to predict such a lifetime, at least

PHOTO SEQUENCE using Pegasus model shows how Fairchild-

for the first vehicle. They believe the lifetime is apt to improve in the next two vehicles.

Pegasus was launched into an orbit inclined 31.76 degrees and with an orbital period of 97 minutes—both exactly as planned.

With its wings fully extended, *Pegasus* is 96 ft. wide and, remaining attached to the *Saturn* S-IV stage in orbit, measures 61 ft. in length. Total weight —including the *Saturn* instrument unit, support structures and adapter—is 23,000 lbs. *SA-9* also carried a 10,000-lb. boilerplate *Apollo* Command and Service Module into a separate orbit (the Service Module provided the protective housing for *Pegasus* during launch), as well as some 700 lbs. of residual fuel aboard the S-IV. This fuel eventually evaporated.

The next two *Pegasus* launchings are scheduled to come in the second and third quarters of this year aboard *SA-8* and *SA-10,* which will also close out the *Saturn I* program. Both are near-Earth orbital shots.

SA-9 was actually the eighth in the *Saturn 1* series and the last to use the MSFC-produced S-I first stage. *SA-8,* which was originally to have been ready first, and *SA-10* use the first S-I stages to be turned out by the Chrysler Corp. at NASA's Michoud Operations near New Orleans.

• **Modifications**—While *SA-9* was basically the same vehicle as its predecessors, there were some changes. Most important of these was the first flight of the redesigned IU, which cut weight of the unit in half and also shortened the length. MSFC switched to an unpressurized IU representative of the type to be flown aboard the *Saturn IB* and *V*.

A center hub carrying pressurized gas cans was eliminated, as was the need to carry purge gas, and the IU components were mounted around the inside perimeter of the 154-in. IU cylinder. The *SA-9* weighed 2,600 lbs., compared with *SA-7*'s 5,400 lbs.

SA-9 also used an auxiliary nonpropulsive vent system with the Douglas-built S-IV stage's hydrogen tank, to improve orbit stabilization and reduce tumbling. The stage was coated with a special paint to cut heat absorption, which could have upset the satellite's thermal balance.

• **Unique satellite**—*Pegasus* is part of the meteoroid detection program sponsored within NASA's Office of Advanced Research and Technology, bringing that agency into the *Saturn* program for the first time. MSFC is project manager for the satellite and launch vehicle. Fairchild-Hiller Corp. is prime contractor, supported by a tier of 13 major subcontractors.

Heart of the satellite is the deployable 96-ft. wing structure and the thin-film array of detector-capacitors, built by G. T. Schjeldahl Co., which serve to detect and record meteoroid impacts. The usable experimental surface exposed to the environment aboard *Pegasus* is about 80 times greater than the detection areas aboard earlier satellites, such as *Exporers XVI* and *XXIII,* from which many of the current basic meteroid statistics have been extrapolated.

Each *Pegasus* wing consists of seven hinged frames deployed by a scissor-type linkage connected to a motor and torque tube assembly. There are 208 20 x 40-in. panels mounted on the frames on each side of the wings, making 4,166 panels in all, each an individual sensor. There is more than 2,300 sq. ft. of detector space. An inch-thick polyurethane foam core separates the two sides.

Each detector consists of an outer sheet of aluminum backed by a three-layer Mylar sheet 50 microns thick. Behind this is a 25-micron layer of vapor-deposited copper. The outer aluminum target sheet is used in three different thicknesses aboard *Pegasus*, providing data on penetrations at various meteroid energy levels. About 80 sq. ft. of detector space will be covered with 1.5-mil aluminum. About twice that much will be covered with an 8-mil thickness and some 1,700 sq. ft. will use 16-mil aluminum.

The copper layer of the detector is charged with 40 volts dc, so that when a particle penetrates the aluminum and Mylar layers, the copper layer discharges by way of a gas-like ionized plasma created by the impact of the micron-sized particles. The plasma, which acts as a conducting patch between the capacitor plates, dissipates rapidly so that the capacitor can be recharged by the *Pegasus* battery. The resultant current drain is sensed, and this in effect records the impact.

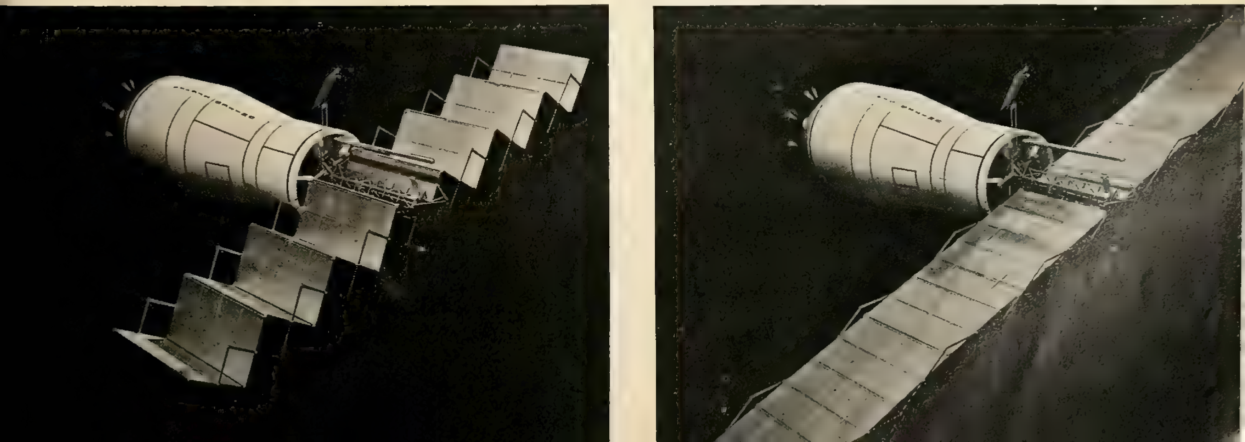
• **Problems**—The levels of impact energy can be differentiated through the use of the panels of varied thickness; on-board electronics record which panels are hit and how often. Spacecraft attitude information is important in measuring meteoroid direction. The satellite position at time of impact is read out of a system of five solar sensors and 12 IR Earth sensors, in addition to known orbital position. However, the tumbling of *Pegasus* in orbit, caused mostly by gravitational action on the oddly shaped craft, complicates the attitude sensing.

One other *Pegasus* problem involves a characteristic of Mylar which tends to cause it to discharge; an effect similar to that caused by an impact. Electrons build up as they might during exposure to Van Allen belt radiation.

Fairchild engineers report that special discriminator circuitry has been built into the system to help differentiate between the two discharges, and that 10 panels are not charged with the 40 volts—so that any discharge coming from these will quickly indicate an electron build-up.

Pegasus also carried two small piggyback experiments into orbit. One is a TRW Space Technology Laboratories device to measure electron activity at two different energy levels. The other is an MSFC thermal coating test, in which four lenses with different coatings will be evaluated for future spacecraft use. ■

ellite deploys wings with 2,300 sq. ft. of detector space to 96-ft. span.



Decision Imminent on Standard Atlas

Space agency may be at odds with DOD, which has okayed Titan III-A/Agena; NASA reveals cancellation of Floxed Atlas

by Hal Taylor

NASA AND DOD are expected to decide within the next two months whether to proceed with the proposed uprated standardized *Atlas* SLV 3X launch vehicle.

The imminence of the decision on the program was learned as NASA Fiscal Year 1966 budget documents revealed that plans to uprate the *Atlas* by adding fluorine oxidizer have been cancelled.

No funding for the Floxed *Atlas* program is included in the space agency's FY '66 budget request of $797.5 million for the Office of Space Sciences and Applications (OSSA). The effort was funded by the agency in the two previous fiscal years. It is being dropped, NASA officials said, because of its tight overall budgetary position—and the fact that the uprated *Atlas* is considerably more attractive.

A high-level official in NASA's launch vehicle program told MISSILES AND ROCKETS that "we look favorably on approval of the SLV 3X," which could be used to launch a host of scientific Earth-orbit, lunar and planetary spacecraft.

• **Cool toward Titan**—The agency position could put it in direct conflict with the Dept. of Defense, which recently announced approval of the *Titan III-X/Agena* booster. The two launch vehicles have just about the same payload capability.

While DOD's plans are not known, it is possible that defense officials will try to get NASA to use the *Titan III-X* for its unmanned space missions.

The NASA launch vehicle spokesman said the agency has no current plans to use the *Titan III-X*.

He said the new DOD booster would be more expensive, require new launch facilities at Cape Kennedy, and force NASA to enter into a new contractor relationship. All of these things, he added, would cost NASA money—"funds which just aren't available to us."

He also commented that *Titan III-X* has not yet proven its reliability, while the *Atlas* has chalked up about 20 successful launches for NASA.

The SLV 3X payload performance would be uprated by 30% over the current *Atlas* vehicle primarily by such modifications as engine changes, miscellaneous weight reduction, decreased propellant pads, tank geometry changes and associated ground equipment changes.

The resulting increase in payload would be only slightly below the *Titan III-X/Agena* payload of about 7,000 lbs. in Earth orbit.

The future of the SLV 3X currently is being considered by the joint NASA/DOD Aeronautics and Astronautics Coordinating Board. NASA has already presented its position favoring hardware development, but DOD's view still has not been made public. Still to be determined, assuming development is approved, is which agency will pay for it.

• **Few surprises**—Cancellation of the Floxed *Atlas* program—which was not announced by NASA in its budget briefings for the press—is one of the few surprises disclosed by detailed information which it recently presented to Congress to support its FY '66 budget request. Officials had originally planned to flight-test two fluorine/oxygen-powered *Atlas* vehicles, but this has now been dropped. There is a possibility that the project could be revived in FY '67, but officials said this is unlikely.

Another major surprise in the new OSSA budget is the addition of another spacecraft in the *Nimbus* program. Hardware development of the *Nimbus D* will be started in the next fiscal year, and its estimated total cost will be $22 million. It makes a total of four spacecraft in the program.

Nimbus A was launched on Aug. 28, 1964. It will be followed by *Nimbus C*—now scheduled to be launched in 1966—and *Nimbus B* in 1967.

Another major new program—Project *Voyager*—is ticketed for $40 million for spacecraft bus design studies, $2 million for experiments and $1 million for ground operations.

• **New studies**—In addition to the funding of currently authorized programs, funds in the supporting and research and technology projects provide for various new programs and experiments.

In the physics and astronomy area, $25.2 million has been asked for studies in such areas as particles and fields, ionosphere and radio physics, planetary atmospheres and space chemistry, interplanetary dust and cometary physics, solar physics, astronomy and geodesy, spacecraft technology, interdisciplinary space science, manned space science and advanced studies.

The advanced studies request of $900,000 includes work leading to the development of standardized modules for *Explorer* spacecraft, studies of concepts for manned orbiting telescopes to be assembled and maintained by men in space, and a start on the feasibility study of advanced Radio Astronomy satellites.

In the launch vehicle area, part of the $4-million request for supporting research and technology will be used for continued study of a high-energy kick stage for high-velocity missions. Work will be continued in FY '66 on the guidance system, propulsion technology and other vehicle subsystems. Hardware development of the 7,000-lb.-thrust stage is expected to be ordered in FY '67.

• **Cameras, etc.**—Part of the $8.2 million for meteorological systems SR&T will be used to initiate an improved automatic picture-taking camera storage system, a pre-prototype bi-fold solar paddle array, a compatible ground station for an on-board digital TV system providing improved accuracy and longevity, a long-life control system, and a pre-prototype interrogation, recording and location subsystem to investigate satellite measurement of the atmospheric structure.

In the area of meteorological experiments, some $4 million is allotted for procurement of low-resolution cameras, including image dissectors or image motion compensation devices, additional zoom lenses for the high-resolution camera for the *Applications Technology Satellite* (*ATS*) missions. ■

NASA SPACE SCIENCE & APPLICATIONS FY'66 R&D REQUEST

(in millions of dollars*)

	1965	1966
SOLAR OBSERVATORIES		
Orbiting Solar Observatory (OSO)		
Spacecraft	$ 5.6	$ 6.1
Experiments	4.2	5.3
Subtotal OSO	9.9	11.4
Advanced Orbiting Solar Observatory (AOSO)		
Spacecraft	5.76	19.2
Experiments	1.57	5.9
Ground operations	.06	.5
Subtotal AOSO	7.4	25.6
Total OSO & AOSO Spacecraft & Support	**17.3**	**37.0**
Delta	**(.36)**	**(1.4)**
TOTAL (including launch vehicles)	**(17.66)**	**(38.4)**
ASTRONOMICAL OBSERVATORIES		
Spacecraft	21.89	25.6
Experiments	9.3	6.9
Total spacecraft & support	**31.2**	**32.5**
Atlas-Agena (launch vehicle procurement program)	9.0	15.1
TOTAL (including launch vehicles)	**40.2**	**47.6**
GEOPHYSICAL OBSERVATORIES		
Spacecraft	17.0	18.8
Experiments	12.36	12.2
Ground operations	.86	.7
Total spacecraft & support	**30.2**	**31.7**
Atlas-Agena (launch vehicle procurement program)	(3.67)	(13.59)
Thor-Agena (launch vehicle procurement program)	(4.45)	(.8)
TOTAL (including launch vehicles)	**(38.36)**	**(46.1)**
EXPLORERS		
Geophysical & interplanetary Explorers	16.77	15.6
Astronomy Explorers	1.1	6.1
Geodetic Explorers	4.0	4.0
Total Explorers	**21.95**	**25.7**
Scout (launch vehicle procurement program)	(4.29)	(7.7)
Delta (launch vehicle procurement program)	(12.35)	(9.5)
Thor-Agena (launch vehicle procurement program)	(11.56)	(4.1)
TOTAL (including launch vehicles)	**(50.16)**	**(47.0)**
SOUNDING ROCKETS		
Experiments	7.79	8.2
Rocket development	.6	.7
Attitude control systems	1.09	1.5
Engineering support	.3	.5
Test and evaluation	.2	.2
Ground instrumentation	2.8	2.8
Rocket procurement	3.1	3.1
TOTAL	**16.0**	**17.0**
DATA ANALYSIS		
TOTAL	—	**3.0**
LUNAR & PLANETARY SUPPORTING RESEARCH & TECHNOLOGY		
TOTAL	**28.7**	**36.8**
RANGER		
Spacecraft	8.36	.6
Experiments	4.1	.8
Ground operations	2.7	—
Total spacecraft & support	**15.25**	**1.4**
Atlas-Agena (launch vehicle procurement program)	(3.1)	(.2)
TOTAL (including launch vehicles)	**(18.38)**	**(1.6)**
SURVEYOR LANDER		
Spacecraft	64.46	64.87
Experiments	6.89	15.97
Ground operations	4.65	4.76
Total spacecraft and support	**76.00**	**85.60**
Atlas-Centaur (launch vehicle procurement program)	(47.80)	(50.40)
TOTAL (including launch vehicles)	**(123.80)**	**(136.00)**
LUNAR ORBITER		
Spacecraft	40.6	32.9
Experiments	—	.5
Ground operations	1.8	3.6
Total spacecraft and support	**42.4**	**37.0**
Atlas-Agena (launch vehicle procurement program)	(2.3)	(22.2)
TOTAL (including launch vehicles)	**(44.7)**	**(59.2)**
MARINER		
Spacecraft	14.05	1.25
Experiments	2.46	1.8
Ground operations	4.47	.7
Total spacecraft and support	**21.0**	**3.8**
Atlas-Agena (launch vehicle procurement program)	(2.37)	(.2)
TOTAL (including launch vehicles)	**(23.37)**	**(4.0)**
VOYAGER		
Spacecraft	7.15	40.0
Experiments	.2	2.0
Ground operations	.4	1.0
TOTAL	**7.75**	**43.0**
PIONEER		
Spacecraft	12.3	5.5
Experiments	1.4	2.1
Ground operations	1.26	.4
Total spacecraft and support	**15.0**	**8.0**
Delta (launch vehicle procurement program)	(2.9)	(5.9)
TOTAL (including launch vehicles)	**(17.9)**	**(13.9)**
UNIVERSITY PROGRAM		
TOTAL	**46.0**	**46.0**

	1965	1966
LAUNCH VEHICLE SUPPORTING RESEARCH & TECHNOLOGY		
TOTAL	**7.1**	**4.0**
CENTAUR DEVELOPMENT		
Vehicle development	77.3	39.5
Supporting services	3.8	1.5
Tracking instrumentation	.08	.1
Atlas boosters	4.25	—
RL-10-A3 engine development	—	—
Propellants	3.69	5.5
RL-10-A3 engine improvements	—	13.0
TOTAL	**89.4**	**59.6**
SCOUT PROCUREMENT		
Vehicles	4.09	5.75
Motors	1.3	1.65
Logistics and other	.3	.3
Sustaining engineering & maintenance	7.5	4.0
TOTAL	**13.19**	**11.7**
DELTA PROCUREMENT		
Delta stages	14.99	21.5
Thor boosters	10.2	3.7
Propellants	.25	.25
Third stages	.26	.42
Sustaining engineering & maintenance	6.9	4.8
TOTAL	**32.65**	**30.7**
AGENA PROCUREMENT		
Agena production	14.7	17.26
Agena mission modifications	15.59	28.79
Thor procurement	4.8	3.98
Propellants	.6	.46
Sustaining engineering & maintenance	14.05	5.7
TOTAL	**60.04**	**82.3**
CENTAUR PROCUREMENT		
Vehicle production	24.05	28.9
System integration	2.0	3.99
Atlas procurement	12.59	12.7
RL-10 engine procurement	5.8	3.25
Propellants	3.3	1.5
Sustaining engineering & maintenance	—	19.4
TOTAL	**47.8**	**69.8**
BIOSCIENCE SUPPORTING RESEARCH & TECHNOLOGY		
TOTAL	**12.7**	**15.5**
FLIGHT PROGRAM (BIOSATELLITE)		
Spacecraft	11.19	10.2
Experiments	4.56	4.2
Ground operations	.25	1.6
Total spacecraft and operations	**16.0**	**16.0**
Delta (launch vehicle procurement program)	(9.0)	(9.1)
TOTAL (including launch vehicles)	**(25.0)**	**(25.1)**
METEOROLOGICAL SUPPORTING RESEARCH & TECHNOLOGY		
TOTAL	**7.5**	**8.2**
TIROS		
Spacecraft	1.4	.6
Ground support	1.25	1.8
TOS improvements	1.45	2.4
Total spacecraft and support	**4.1**	**4.8**
Delta (launch vehicle procurement program)	(1.1)	(—)
TOTAL (including launch vehicles)	**(5.2)**	**(4.8)**
NIMBUS		
Spacecraft	8.7	10.8
Experiments	4.1	6.7
Ground operations and support	3.2	5.2
Total spacecraft support	**16.0**	**22.7**
Thor-Agena (launch vehicle procurement program)	(6.35)	(6.2)
TOTAL (including launch vehicles)	**(22.35)**	**(28.9)**
METEOROLOGICAL SOUNDING ROCKETS		
Large meteorological sounding rocket project	1.9	1.9
Development of small meteorological sounding rocket system	.4	.5
Field experiment support	.06	.06
TOTAL	**2.4**	**3.0**
APPLICATIONS SUPPORTING RESEARCH & TECHNOLOGY		
TOTAL	**2.1**	**2.5**
RELAY		
Ground operations and support	.5	.2
TOTAL	**.5**	**.2**
SYNCOM		
Spacecraft	.05	—
Ground operations and support	.16	.1
TOTAL	**.21**	.1
APPLICATIONS TECHNOLOGY SUPPORTING RESEARCH & TECHNOLOGY		
TOTAL	**1.7**	**2.0**
APPLICATIONS TECHNOLOGY SATELLITES		
Spacecraft	18.8	24.1
Operational support	2.86	2.6
Total spacecraft and support	**21.69**	**26.7**
Atlas-Agena (launch vehicle procurement program)	(3.05)	(14.2)
TOTAL (including launch vehicle)	**(24.75**	**(40.9)**

* Figures rounded off to nearest million.

In posture statement . . .

McNamara Stresses Air Defense System

Surface-to-air missile, probably of AADS-70 type, getting new funding; eventual Nike-X production hinted; MOL broadening detailed

AN ADVANCED air defense system effective against high-speed aircraft and short-range missiles was emphasized for the first time by Defense Secretary Robert S. McNamara in his military posture statement before the House Armed Services Committee. McNamara noted that the Fiscal Year 1965 budget included a $5-million request to initiate advanced development of the surface-to-air system, designed to be operational in the 1970's.

This probably was a reference to the *AADS-70* program, long in a "back-burner" status, or an adaptation of this program.

The FY '65 appropriation for the system has been increased through reprogramming, and additional funding is being requested in the FY 1966 budget. McNamara noted that the missile is intended for application to air-defense problems in the field but could also be used for continental defense.

Another new note in the posture statement was the first hint of any funding relating to eventual *Nike-X* production. In announcing a $400-million request for continued *Nike-X* development in FY '66, McNamara observed that this amount includes "$10 million for some preliminary production engineering."

The defense secretary confirmed a broadening of the objectives of Air Force's *Manned Orbiting Laboratory* (*MOL*) program, including: 1) development of technology contributing to both manned and unmanned space operation; 2) development of manned capability to assemble and service large orbiting structures; and 3) other manned military space experimentation. In addition, *MOL* will be used to investigate servicing and assembly of non-military structures (telescopes, radio antennas, etc.) and will progress to study man's biological responses during periods in orbit of as long as 30 days.

- **MOL dissembling**—Proposals from industry contractors were submitted to the Air Force Space Systems Division in Los Angeles Feb. 15, outlining how these firms would manage and develop the expanded *MOL* concept. Requests for proposals were sent to 22 firms. The Pentagon has refused to release either the number or the names of contractors submitting proposals. An unusual procedure in view of this censorship was the mailing of letters to all members of Congress who have potential *MOL* contractors in their constituencies, informing them that these firms had received requests for proposals.

Most knowledgeable Washington sources are convinced that the Air Force has already picked the two or three prime contractors who will be the competitors in the program. They have concluded that requests for proposals on complex management techniques, due within 30 days, were, in the words of one observer, "only a means of seeing that nothing really good is overlooked and a method of avoiding the charges of favoritism that intruded themselves into the F-111 selection decision."

Text of McNamara's statement confirmed deletion of the *Satellite Inspector* project from the FY 1966 budget. Noting that this proposed system proved "extremely expensive," McNamara said "much of the fundamental technology is now being pursued through other means"—rendezvous in the *MOL* program and inspection through two large ground-based optical programs at Cloudcroft, N.M., and Maui, Hawaii.

- **Other missiles**—The *Hawk* missile will undergo an improvement program designed to make it effective against "some tactical missiles," McNamara said. A total of $11 million is requested for this purpose. An "Advanced Anti-radiation Missile System" is contemplated as a follow-on to the *Shrike*. Although Navy will do the work on the subsystems, both Army and the Air Force are interested in this missile development.

The FY 1966 defense budget contains a modest $6-million request for continued feasibility study of components which would provide a design basis for a chemical-powered supersonic, low-altitude vehicle. Again, in FY 1966, the Army funding requests for its *Lance* surface-to-surface field missile indicate no preparation for production support. First flight of the experimental missile is scheduled for this month.

Total cost of development of Navy's *B-3 Polaris* (*Poseidon*) missile is expected to reach $900 million, McNamara said. To initiate project definition in this program, $10 million of available FY 1965 funds will be used—plus a requested $35 million in FY 1966. If the cost of retro-fitting 19 *Polaris* submarines to carry these missiles is considered, McNamara estimated, total cost of the program could reach $2 billion, "including the cost of missile development and production."

The Navy's new standardized surface-to-air missile, the planned replacement for the *Terrier-Tartar-Talos* series, was characterized as "well along in development." McNamara indicated the Navy plans "to buy a number in FY 1966 for operational test and evaluation." The three-T "get well program" for improvement of *Terrier, Tartar* and *Talos* has absorbed funds totaling $108 million in the FY 1963-65 period and $39.6 million more is included in FY 1966. Development of the standardized missile is a part of this overall effort, known as the SAM improvement program.

- **Space inroads**—New maneuvering capability in space is being sought with the request for $7 million for a chemical rocket able to execute "efficient multiple re-starts in a space environment, limited only by the availability of propellants."

The FY 1966 defense budget also requests $10 million for funding of an "Advanced Space Guidance" program. Formerly titled "Standardized Space Guidance," this effort is now being pushed as an advanced development program, McNamara said. "It was determined that the first priority was the development of advanced components and subsystems from which a complete guidance subsystem could be developed," he observed.

McNamara estimated that about one quarter of the $316 million requested for FY 1966 exploratory development will be "devoted to space or space-related subjects." Emphasis will be placed on new propulsion cycles for hypersonic manned systems, over-the-horizon radars, command and control, and intelligence techniques. ■

Transtage outdoes itself . . .

Titan III-A Hits Near-Perfect Orbit

Booster and payload expected to have 2,000-year lifetime; MIT experimental satellite misses elliptical orbit when motor fails

by Donald L. Zylstra

THE *TITAN III-A* fired successfully from Cape Kennedy Feb. 11 achieved the most nearly perfect circular orbit in U.S. space history. The Transtage with it double payload went into a final circular orbit with an apogee of 1,506 n. mi., and perigee of 1,502 n. mi. Inclination is 32.1 degrees and the period 145.4 minutes.

The Transtage "space switch engine" about which so many doubts had been voiced exceeded the most optimistic hopes of project people both in the Air Force and among Martin engineers and designers. The orbital eccentricity figure (.00045) produced a circle better than the most perfect ball bearing ever produced and 100 times closer to perfection than the Moon's orbit of the Earth. The Transtage, its standard ballast "truss" payload, and the *LES-1* Lincoln Laboratory experimental communications payload are "likely to remain in orbit 2,000 years," Martin scientists estimate.

In merely boosting the standard truss assembly and the *LES-1* into 1,500-mi. orbit, the Transtage performed its primary mission admirably. The orbiting of the 69-lb. communications experiment was a welcome bonus.

- **New satellite**—*LES-1* was developed by Lincoln Laboratories to test: 1) an all-solid-state X-band communications transponder; 2) an Earth-sensing and antenna-switching system; and 3) a magnetic system for spin-axis control to aid thermal balance in the satellite.

LES-1 was carried into orbit attached to the *Titan III-A* standard ballast truss, a device resembling a four-legged milk-stool, designed to pick up hard points at station 77 on the Transtage vehicle. A 30-in.-dia. tube through the center of the "seat" of the stool is designed to carry lead weights attached outside as needed to achieve the desired center of gravity and moment of inertia.

All the elements related to the *LES-1* payload—including its integral timer, its solid rocket motor, spring assemblies and the 69-lb. *LES* satellite itself—weighed a total of 350 lbs. Combined with the truss assembly, they brought the weight boosted into orbit by the Transtage to 1,070 lbs.

In the parking phase, the Transtage and its payloads attained an orbit with an apogee of 108.9 n. mi, and a perigee of 97.5 n. mi. The period was 88.2 minutes. Nominal or planned orbital figures in each case were: near-Earth circular orbit—apogee, 105.8 n. mi. and perigee, 97.1 n. mi.; 1,500-mi. circular orbit—apogee 1,501 n. mi. and perigee, 1,500 n. mi. Planned orbital period in final orbit was 145.3 min., as against an actual period of 145.4 min. Inclination was exactly 32.1 degrees, as planned.

- **Well oriented**—Preliminary telemetry from the *LES-1* polyhedron-shaped satellite indicates that the satellite's solar cells are furnishing the power for the signals and the antenna-switching system is working well enough so that one of its eight antennas is always directed at the ground receiving stations. The third primary experiment in the vehicle is a magnetic spin-axis orientation control, to provide even heating in the satellite by keeping its spin-axis perpendicular to the Sun's rays, directing them at the satellite's equator as it rotates 180 times per minute.

LES-1 satellite, built by MIT's Lincoln Lab, is gathering military comsat data.

A built-in timer will turn off the solar power to all *LES-1* electronic equipment at the end of a two-year period to prevent unwanted signals once it his served its designated purpose in space.

Fifty seconds after the third burning of the Transtage, with Transtage, truss, and *LES* still attached and in a 1,500-mi. circular orbit, a signal from the *Titan III-A* Transtage guidance system started the spin-up of the *LES-1*. Six torsional springs were released to start the spin. Within less than a half second the spin rate reached the desired 180 revolutions per minute.

Within .4 secs. from the initiation of the spin-up signal, a timer in the *LES* package fired explosive squibs permitting a spring to send the *LES* away from the truss at the rate of five feet per second.

Two seconds from the initial spin-up signal, the Transtage guidance system signaled explosive bolts to fire, separating the truss from the Transtage. Separation was achieved by venting pressurant gas from the Transtage tanks through special nozzles, backing the Transtage away from the truss payload. All these maneuvers were apparently completed successfully in the Feb. 11 launch, with all separations completed as planned.

- **Lost orbit**—But the *LES-1* solid-propellant motor which should have fired on the timer signal, sending the *LES* into a highly elliptical orbit with an apogee of about 10,000 n. mi. and a perigee of 1,500 n. mi., failed to fire. Thus the *LES-1* is now in the same 1,500-mi. circular orbit with the burned out Transtage and the Transtage standard ballast payload or truss.

Telemetry from *LES-1* appears to be good. But the elliptical orbit, had it been achieved, would have provided better returns from both of MIT's two ground stations—at Westford, Mass., and Pleasanton, Calif., since a longer period for observations and measurements would have been available than in the lower-apogee circular orbit. ■

NEW

INSTRUMENTATION TELEVISION CAMERA

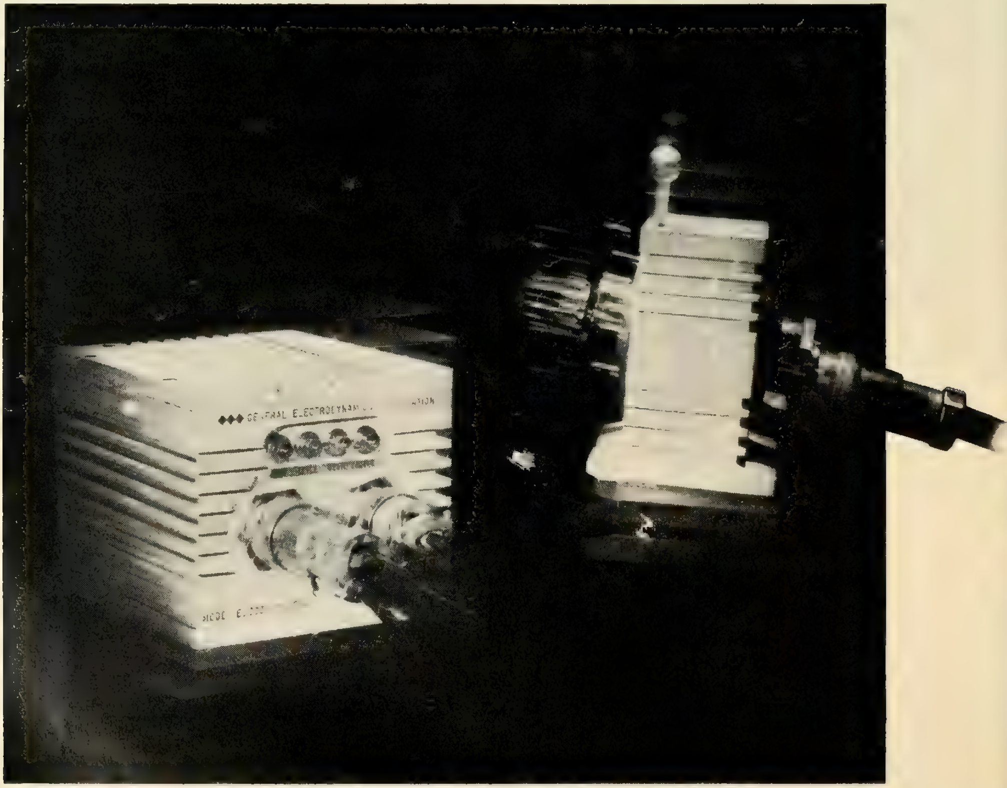
OPERATES IN EXTREME ENVIRONMENTS

The ED 6038 miniaturized instrumentation television camera was designed by General Electrodynamics Corporation to operate in the extreme environment existing within the engine compartment of the largest space boosters, such as Saturn. The high quality pictures produced during this severe environment will provide direct, real-time observation of events while they are happening.

This compact, light weight camera is available in a number of configurations with a wide selection of accessories from General Electrodynamics.

ENVIRONMENTAL CHARACTERISTICS:

20g RMS
60g RMS for 5 sec
20 cps — 2000 cps random
Shock: 100g for 11 ms
Altitude: Space environment
Acoustical Noise: +175 db
Temperature: —10°C to +71°C operating
—10°C to +125°C non-operating
Explosion Proof



GEC®

GENERAL ELECTRODYNAMICS CORPORATION

4430 FOREST LANE • GARLAND, TEXAS • BROADWAY 6-1161

Circle No. 7 on Subscriber Service Card

Technical Countdown

ADVANCED MATERIALS

St. Venant's Principle Explained

Better structurally designed spacecraft and missiles will probably result from an IBM researcher's solution in equation form of a broad assumption made by mathematicians and stress analysts for more than a century. St. Venant's principle, which says that local stresses put into a structure are soon diffused throughout the structure, is given quantitative backing by Dr. Richard A. Toupin, whose equation predicts the decay of local stresses within a real material. Specifically, it expresses the ratio of the elastic energy $U(s)$, stored at some distance s beyond the loaded end, to the total elastic energy $U(o)$ stored in the entire body:

$$\frac{U(s)}{U(o)} \leqq e^{[(t-s)/s_c t]}$$

where t is the thickness of the cross-sectional slice, and s_c is a factor which includes 1) the lowest vibrational frequency of the slice, 2) density, and 3) the maximum elastic modulus. Once the energy has been estimated, it is possible to estimate the stresses at interior points in a body, or points near the smooth part of the surface.

Film Evaporation Back in Running for Desalting

Two engineering teams from the University of Toronto have come up with a pair of techniques claimed capable of cutting the cost of desalting sea water through evaporative means by 24%. The first involves using acid resins to soften sea water before it enters the evaporators. Backwashing techniques cut the resin bed thickness from 6 ft. to 4 in. The second major innovation is the use of Teflon dots in the boiler tubes, thus capitalizing on that material's hydrophobic nature to induce bubbling at only 1° above the theoretical boiling point of water. This increases the formation of bubbles while reducing the energy input necessary. Bubble formation is uniform.

PROPULSION

Full-Scale Hot-Gas Valve Test Slated

The recent success in using hot combustion gases generated in solid rocket motors for directional control will lead to a full-scale test of a hot-gas valve concept in a 156-in.-dia. motor at Lockheed Propulsion Co. Scheduled for mid-1965, the 156-in. motor test follows hard on the heels of scaled testing in Lockheed's char motor using 12 tons of uncured propellant. The valve, built by the electromechanical division of Thompson Ramo Wooldridge, ducts the hot gases from the combustion chamber into the nozzle area—creating a shock wave and thrust deflection similar to that obtained with liquid thrust vector control methods. The hot-gas approach eliminates the auxiliary equipment, tankage, and liquid supply needed for liquid TVC. In addition, hot-gas TVC efficiency can be significantly greater than liquid injection where large and repeated control forces are required, says Lockheed Program Manager H. N. Brownson.

Beryllium Motors Tested for Surveyor

Two more full-scale motors are scheduled to be fired soon by Atlantic Research Corp. and Thiokol's Wasatch Division in a Jet Propulsion Laboratory program to demonstrate the feasibility of using beryllium instead of aluminum additive in the advanced *Surveyor* retro motor. The program recently recorded the longest duration firing of a beryllium motor to date—more than 40 sec.—when ARC tested a full-scale advanced *Surveyor* retro motor loaded with more than 1,000 lbs. of propellant, spokesmen reported. The program, which involves company as well as NASA funds, calls for ARC to fire two full-scale motors, and Thiokol one plus some subscale rockets. The first firing by ARC showed that the nozzle survived very well despite earlier work that indicated beryllium has a greater erosive effect on nozzle materials. It was thought earlier that higher performance of the beryllium additive would have to be paid for by beefing up nozzle hardware.

ASTRONAUTICS

Solar Constant Error May Be ± 5%

Suggesting that estimates of the total flux of solar radiation may be in error by ±5%, Dr. A. J. Drummond, Eppsley Laboratory, has urged that a new determination of the solar constant be made as soon as possible. He pointed out that uncertainties of 50% have been admitted in use of a low-current carbon arc to calibrate sounding rocket ultraviolet spectrograms obtained by the Naval Research Laboratory. Speaking at the International Symposium on Solar Radiation, Drummond said that attempts to match the solar spectrum in simulators had been much overdone, because this was not known well enough, particularly below 6,000 Angstroms, the region of chief concern in spacecraft design.

Moonshine and Earthshine at MSC

The 55-ft.-dia. "A" chamber at the Manned Spacecraft Center, Houston, will simulate the effects of albedo and planetary radiation on complete *Apollo* Command and Service Modules. Aim is to simulate the heat flux caused by secondary radiation in 100 to 200-mi. Earth orbits and 10 to 100-mi. lunar orbits. In Earth orbit, heat input from secondary radiation can exceed that from primary solar radiation. Within the 90-ft.-tall chamber, an irradiated volume 15 ft. in diameter by 55 ft. tall is achieved from a modular radiator array supplied by Honeywell. The vehicle can be rotated within this volume. A hybrid control system involving a digital computer and various mechanical and analog systems programs the secondary radiation to simulate orbital conditions.

SPACE MEDICINE

Minuteman Launch Controllers' Blood Changes

A slight decrease in hematocrit and hemoglobin values of two test subjects after 30 days' confinement in an underground *Minuteman* missile launch control center has been observed. Air Force School of Aerospace Medicine and The Boeing Co. monitors said that this was presumably related in some way to restricted activity, since blood pressure and other measurements after the study suggested no cardiovascular deconditioning of a degree which would interfere with operational effectiveness. The men were maintained on a near-sea-level atmosphere, ate freeze-dried food and performed mission-type tasks during the confinement. Performance was high—99.75%—with no critical errors throughout the period.

Seismic Array Refines Blast Detection

Super-sensitive ARPA device designed to pick up detailed underground test data; could lead to ban on all nuclear tests

by William S. Beller

NATIONS MAY SOON be able to detect and locate by remote means the source of even small underground nuclear explosions.

This is the promise the Advanced Research Projects Agency (ARPA) sees in an exceedingly large array of seismic sensors the agency is setting up near Miles City, Mont.

Acting like a directional antenna, the system possibly will be up to 20 times more effective than any seismograph in the free world. This has broad implications. In the normal test environment of alluvium, an underground explosion of 10 to 20 kilotons can usually be detected by remote seismographs. The new system may be able to detect and locate explosions as small as one kiloton.

This high sensitivity could lead to learning much more about the Soviet program of underground nuclear testing and, from this, the state of that country's warheads for tactical missiles.

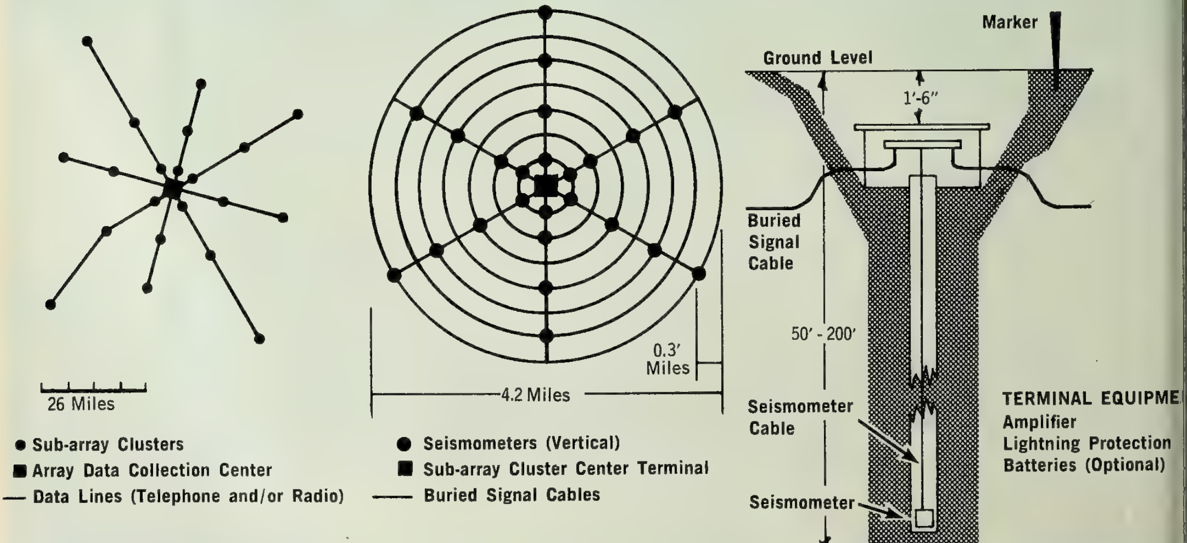
- **Effect on tactical missiles**—Lack of agreement on a way to detect underground explosions led to the 1963 U.S.-USSR nuclear test-ban treaty's concerning itself only with atmospheric testing. However, if a development such as the present one were to result in extending the treaty to underground nuclear explosions, it could have a major effect on the development of tactical nuclear weapons. It could, for instance, lead to a ban on testing warheads of most U.S. tactical missiles: these are tipped with warheads closer to 20 kilotons than the one kiloton that will possibly mark the new threshold of seismic detection. The one exception is *Davy Crockett,* whose effectiveness on the basis of its 0.4-kiloton warhead is questioned by some Army officials.

The new facility is called LASA—Large Aperture Seismic Array. It is capitalizing on developments made under ARPA's Project VELA—the research and development effort for the detection and identification of nuclear explosions. An ARPA scientist likened the new facility, with respect to the scientific data it is expected to generate, to a microscope having an order of magnitude improvement in magnification.

Seismic signatures of many earthquakes as well as underground explosions are expected to be seen in "exquisite detail"; weak earthquakes, which ordinarily would not be perceived by remote seismographs, will probably be picked up in greater abundance. LASA's ability to do the job is based on a design able to vastly increase the signal-to-noise ratio of phenomena of interest within the passing seismic scene.

Although LASA is expected to detect relatively weak seismic disturbances,

LARGE APERTURE SEISMOLOGICAL ARRAY (LASA)


26 Miles
● Sub-array Clusters
■ Array Data Collection Center
— Data Lines (Telephone and/or Radio)
0.3' Miles
4.2 Miles
● Seismometers (Vertical)
■ Sub-array Cluster Center Terminal
—— Buried Signal Cables
Marker
Ground Level
1'-6"
Buried Signal Cable
50' - 200'
Seismometer Cable
Seismometer
5" I.D.
TERMINAL EQUIPME
Amplifier
Lightning Protection
Batteries (Optional)

DISTRIBUTION OF 21 SUB-ARRAY CLUSTERS

SUB-ARRAY CLUSTER CONFIGURATION

SEISMOMETER TERMINAL

one difficulty may lie in pinpointing their depths. This may add to the problem of telling the difference between a small earthquake and an underground explosion. Yet this problem may be solved when LASA starts writing seismic signatures in its clearer hand. Several seismologists meeting at an international conference in London earlier this month agreed that LASA will no doubt be able to discriminate between the short, sharp jolt of an underground explosion and the deep-throated rumble of an earthquake.

At this meeting, R. A. Frosch of ARPA and P. E. Green of MIT Lincoln Laboratory disclosed details of LASA. Lincoln Laboratory and the Air Force Technical Applications Center are the agents and technical helpers for the Miles City array.

To many observers, one of the most exciting features of LASA is that it was developed through the advances in many technical fields seemingly unrelated to seismology. Cross-fertilizations such as this are seen holding answers to many technical problems that could not possibly be solved in terms of one field alone.

- **Array theory applied**—LASA is combining seismological ideas and techniques with those in signal processing, array theory, computer technology and telemetry. One of the most useful concepts introduced to seismologists in recent years "has been that of connecting together a number of sensors distributed in a horizontal plane to form an array," Frosch and Green pointed out. This could be particularly useful in monitoring underground nuclear tests "since the events are of small magnitude and the criteria used to distinguish source type depend on freeing the weak signal as far as possible from both the additive seismic noise and reverberations," they said.

In describing how the LASA design will proceed, Frosch and Green said: "We will bury (sensing) instruments to several hundred feet in order to protect them from local civilization and wind noise. They will be organized into sub-arrays of detectors in order to discriminate against the coherent microseismic noise. By spreading the microseism discriminating sub-arrays over a large aperture, we will construct a directional characteristic that can separate inhomogeneity-scattered, signal-generated noise from principally P- and S-wave paths. Finally, we will make provision for sufficiently sophisticated signal processing so that internal reflection in the crust may be removed by deconvolution. Such an array would pay principal attention to teleseisms occurring 30 to 90 degrees away from it."

- **Shape of the array**—The geometry chosen for LASA is shown in the accompanying diagram. Consisting of 21 sub-arrays, each 7 kilometers in diameter and each having 25 sensors, the total number of sensors is 525. This design was chosen in order to increase the signal-to-noise ratio by a factor between five and 20, probably closer to 20.

Engineers are installing only short-period vertical sensors in the LASA facility. The reason is that for discrimination purposes, the most important part of the teleseismic signal appears to be the compressional energy of the first minute.

"If the overall array proves as successful as hoped in suppressing noise at the low-frequency end," Frosch and Green said, "an extension of sensor response well below the initial design figure of 0.2 cps may be important."

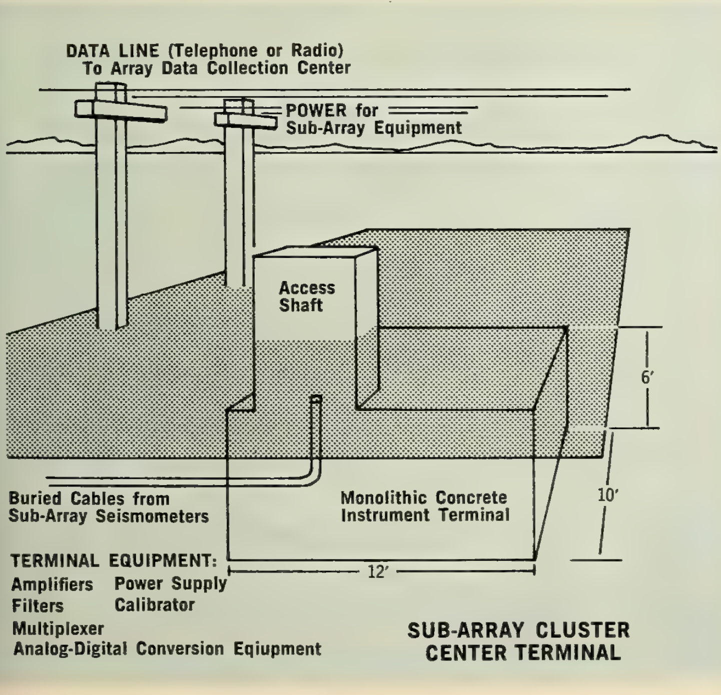
The array is expected to have a threshold of magnitude three for detection of individual events. The magnitude of an earthquake is related to the amount of energy released. The smallest detectable disturbance, with an energy release of 6.3 x 10^5 ergs, is defined as magnitude zero, while the larger ones, with an energy release of about 2 x 10^{25} ergs, are called magnitude 8.5 There are only about a dozen 8.4-magnitude earthquakes over a hundred-year period while there are over 300,000 a year having a magnitude of less than 3.

One possible display of LASA data would be shown on an oscilloscope. "The output of each beam, that is, each direction in vertical and horizontal which may be observed by the array appears as a spot of light," Frosch and Green explained. "This scope face is a mapping of some portion of (the) crust of the Earth within 30 to 90 degrees from the array. Each discrete flicker of light will correspond to an earthquake event of the order of three or greater. The intensity of the flicker would correspond to something of the order of magnitude of the event."

They added that a display of the seismicity of a portion of the Earth would be seen in a continuous picture. An actual tracing of the seismogram from each beam for each event would give the seismic signal from that event "with a clarity not previously available." They forecast that "a system of such arrays properly sited with respect to the seismic regions of the world would give us a new view of seismology." By the same token, it would also give a piercing view of underground nuclear explosions.

At the present time, two clusters of 25 instruments have been completed at the LASA facility and are undergoing engineering test. A contract has been let and work is underway for the construction of the remaining 19 clusters. "We hope to have an array complete in the field with signals from all instruments by June, 1965," according to Frosch. "At that time, we will commence 'off-line' evaluation of the array."

Estimates of LASA's performance are expected by fall and ARPA hopes to be able to complete evaluation of the entire facility by January, 1966. ■



SUB-ARRAY CLUSTER
CENTER TERMINAL

PROGRAMS AT GRUMMAN

are provocative to say the least. Let's start at the bottom (of the sea that is) where Grumman is involved in a number of programs that spans the ASW spectrum. Like oceanography, underwater acoustics and electromagnetic interactions.

Get airborne and find the OV-1 Mohawk STOL electronics surveillance aircraft for a variety of ground forces.

The S2D Tracker, carrier based package of highly specialized electronic systems.

Gain airspeed and reconnoitre the E-2A Hawkeye, sophisticated carrier or land based early warning aircraft. The A6A Intruder that locates, tracks and destroys all types of targets. Supersonic aircraft of a revolutionary character.

Blast off into space with OAO (Orbiting Astronomical Observatory) . . . The LEM (Lunar Excursion Module). Like the man says . . . "a sure cure for professional doldrums." See these specific opportunities at Grumman.

The E-2A Hawkeye is a 'flying brain' designed to provide quick information of impending attack. The aircraft's high resolution radar detects attacking aircraft hundreds of miles away. The E-2A Hawkeye is but one of the varied programs at Grumman.

Structural Designers—BS in CE, ME or AE with a minimum of 3 years experience in the layout and design of aerospace structures.

Environmental Control & Life Support Systems Engineers—BS in Engineering or equivalent experience with background in Environmental and/or Life Support Systems for space and aircraft applications. Scope of work covers all phases from proposal preparation to final system check-out including analysis, design, development, testing, installation, liaison with Manufacturing Dept., Vendors and customers.

Environmental Control & Life Support Test Engineers—Must be experienced in systems testing-development, qualification, functional pre-flight and familiar with instrumentation requirements, laboratory equipment. Should be capable of writing test plans and reports. Manned testing experience desirable.

Rocket Propulsion System Design Engineers—BS in Engineering with experience in design of liquid rocket motors and associated systems. Will be responsible for the conception, analysis and design of storable bi-propellant rocket systems, gas pressurization systems, and cryogenically-fueled power supply systems for space application. Duties also involve design of rocket motor installations and supervision of manufacturers of motors and other components.

Crew Station Designers—BS in Engineering or a minimum of 5 years design experience. Capable in cockpit or spacecraft design including generating own drawings of Crew Station layout. Familiarity with Geometry-Display and control arrangements with supporting knowledge of Human Factors principles and task analysis associated with man-machine relationships is essential. Pilot experience desired but not mandatory.

Fuel Cell Test Engineers—To conduct test programs on space power generation and fuel cell systems. Must have experience with fuel cell operation and test and be capable of writing test plans and reports, specifying instrumentation, and defining test set-ups, test jigs and facility requirements.

Cryogenic System Test Engineers—To conduct test programs on space power generation and supercritical cryogenic H2 and O2 storage systems. Must have experience with cryogenic system operation and test, and be capable of writing test plans and reports, specifying instrumentation, and defining test set-ups, test jigs and facility requirements.

Rocket Propulsion System Test Engineers—Must be experienced in the testing of liquid rocket propulsion systems, cryogenics system and familiarity with techniques, instrumentation and test procedures. Will prepare test procedures, monitor set-up of hardware, conduct tests and prepare test plans and reports.

Reliability Systems Engineers- B.S. in Physics, EE, ME or AE and a minimum of three years professional experience to perform a variety of aerospace vehicle studies with the capability for proposal preparation. Requires a systems perspective, a background in systems design or analysis, an understanding of mission requirements and a desire to perform diverse work under tight schedules. Responsibilities require experience in developing system models at the conceptual design stage for defining mission objectives in terms of reliability, maintainability and operational availability design requirements. Must be capable of performing independent studies and supporting advanced development efforts to advance the state of the art in reliability and availability design techniques. A working knowledge of applied statistics, probability and the methods of operations research is essential.

Reliability Ground Support Engineers—BS in Physics, EE, ME or AE with a minimum of 3 years experience in Reliability and with practical design experience in Aerospace Ground Support Equipment. Knowledge of elements of good reliability programs and command of the state-of-the-art reliability techniques is essential. Must be capable of performing independent design reviews for reliability, in conjunction with maintainability, flight equipment designers and ground support design engineers. Background in statistics, probability and operations research methods desirable.

To arrange an immediate interview,
SEND RESUME to
Mr. P. M. Van Putten,
Manager Engineering Employment,
Dept. GR-86.

GRUMMAN
AIRCRAFT ENGINEERING CORPORATION
Bethpage • Long Island • New York

(An Equal Opportunity Employer)

Circle No. 22 on Subscriber Service Card

Nondestructive Testing Fundamental To Advanced Materials Development

by John F. Judge

LOWELL, MASS.—Nondestructive test techniques have become a prime tool in the effort to produce materials capable of meeting the demands of future weapons and space systems.

Once relegated to a mere inspection function, nondestructive testing (NDT) is now being used at Avco's Research and Advanced Development Division here to quantitatively establish the nature and degree of variability in graphite destined for aerospace applications. The project is funded by the Air Force Materials Laboratory, Research and Technology Division, Air Force Systems Command under the technical supervision of R. R. Rowand and W. L. Shelton.

Carl Hastings, Avco/RAD NDT evaluation section chief, says nondestructive testing should see re-direction with emphasis on quantitative properties measurement, and as an aid to developing new materials. It is still considered primarily an inspection activity in many quarters. Hastings claims inspection is only the operational end of NDT.

The graphite work in progress at Avco will form a basis for evolving a technically sound and economical plan for improving the quality and uniformity of graphite raw stock and fabricated parts.

• **Variability detection stressed**—The key concept in the program is the attack on variability. Hastings says NDT should cease its limited search for flaws and concentrate on material variability of all types. This variability is the primary defect in almost all aerospace materials and Hastings considers most operational failures to be materials failures.

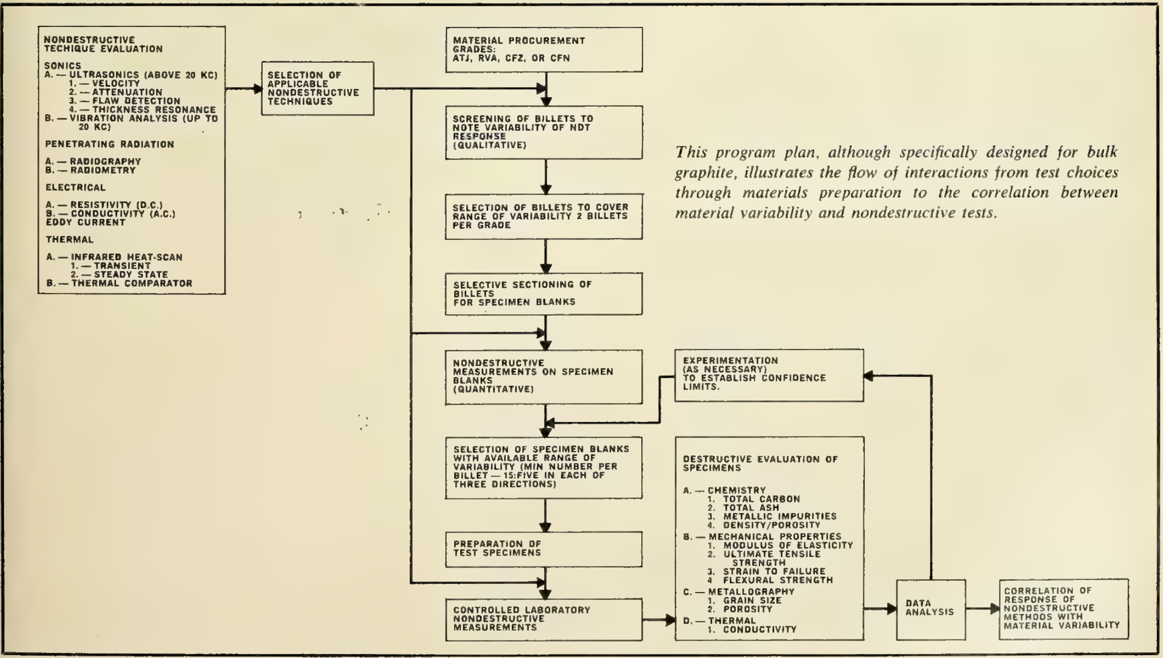
The reasons for failure may be improper selection, application in design, fabrication or inspection. It is the material, however, that fails.

Seeking the reasons for failure leads away from simple flaw detection to include all types of material variability.

In addition, variability should be measured in whatever terms demanded by the designer. Hastings says that when NDT is used as an inspection function only, it frequently provides information on flaws that are often difficult to use in forming acceptance decisions. The job, as he sees it, is to climb upstream in the process and then couch the data derived from intelligent use of NDT in designer language.

Hastings further insists that the burden is on people in the materials field to get better data. This is not meant to be idealistic information but data that realistically shows the range of variability in the material to allow the designer to do his job. The cooperation of the designer can then be enlisted in studying acceptance limits for NDT results.

• **Multiple approach**—Hastings says there is no such thing as a universal


NONDESTRUCTIVE TECHIQUE EVALUATION
SONICS
A. — ULTRASONICS (ABOVE 20 KC)
1. — VELOCITY
2. — ATTENUATION
3. — FLAW DETECTION
4. — THICKNESS RESONANCE
B. — VIBRATION ANALYSIS (UP TO 20 KC)
PENETRATING RADIATION
A. — RADIOGRAPHY
B. — RADIOMETRY
ELECTRICAL
A. — RESISTIVITY (D.C.)
B. — CONDUCTIVITY (A.C.)
EDDY CURRENT
THERMAL
A. — INFRARED HEAT-SCAN
1. — TRANSIENT
2. — STEADY STATE
B. — THERMAL COMPARATOR
SELECTION OF APPLICABLE NONDESTRUCTIVE TECHNIQUES
MATERIAL PROCUREMENT GRADES: ATJ, RVA, CFZ, OR CFN
SCREENING OF BILLETS TO NOTE VARIABILITY OF NDT RESPONSE (QUALITATIVE)
SELECTION OF BILLETS TO COVER RANGE OF VARIABILITY 2 BILLETS PER GRADE
SELECTIVE SECTIONING OF BILLETS FOR SPECIMEN BLANKS
NONDESTRUCTIVE MEASUREMENTS ON SPECIMEN BLANKS (QUANTITATIVE)
EXPERIMENTATION (AS NECESSARY) TO ESTABLISH CONFIDENCE LIMITS.
SELECTION OF SPECIMEN BLANKS WITH AVAILABLE RANGE OF VARIABILITY (MIN NUMBER PER BILLET — 15:FIVE IN EACH OF THREE DIRECTIONS)
PREPARATION OF TEST SPECIMENS
CONTROLLED LABORATORY NONDESTRUCTIVE MEASUREMENTS
DESTRUCTIVE EVALUATION OF SPECIMENS
A. — CHEMISTRY
1. TOTAL CARBON
2. TOTAL ASH
3. METALLIC IMPURITIES
4. DENSITY/POROSITY
B. — MECHANICAL PROPERTIES
1. MODULUS OF ELASTICITY
2. ULTIMATE TENSILE STRENGTH
3. STRAIN TO FAILURE
4 FLEXURAL STRENGTH
C. — METALLOGRAPHY
1. GRAIN SIZE
2. POROSITY
D. — THERMAL
1. CONDUCTIVITY
DATA ANALYSIS
CORRELATION OF RESPONSE OF NONDESTRUCTIVE METHODS WITH MATERIAL VARIABILITY

This program plan, although specifically designed for bulk graphite, illustrates the flow of interactions from test choices through materials preparation to the correlation between material variability and nondestructive tests.

From bioastronautics research
at Lockheed Missiles & Space Company:

A new biotechnology for Man-in-Space

and Man-in-Sea

Though the Astronaut and the Aquanaut will work in vastly different worlds, their basic problems are much the same. Biomedical problems like dysbarism (various gases trapped in the body), oxygen toxicity, anoxia, trace contamination. Psychological phenomena like "aloneness" (it can produce either depression or euphoria) and disorientation. Physical obstacles like the lack of an anchor point against which a man can brace himself to use many types of tools. By conducting studies in these common problem areas, Lockheed's Bioastronautics organization makes research dollars do double duty. Lockheed Missiles & Space Company, Sunnyvale, California: A Group Division of Lockheed Aircraft Corporation.

Lockheed

Physicists and Electrical Engineers for research into

NEW COMPONENT PART CONCEPTS

Unusual opportunities now exist in the field of component development and performance analysis, due to a conceptual approach developed by our Research and Development Laboratories. These positions demand the ability to perform laboratory evaluation on existing components and prepare a critical analysis of their performance. Where the state of the art is a limiting factor, new approaches must be proposed and development work initiated to provide the required component performance.

In the process of developing new approaches to the solution of component problems, papers must be prepared which will be used as the basis for proposals.

Well equipped laboratories are provided in which the applicant can employ the latest techniques in development and instrumentation to assist in the exploitation of his ideas.

Qualifications should include at least a BS degree from an accredited university in Physics or Electrical Engineering. In addition, the applicant must be able to demonstrate 5 to 10 years of progressive creative experience through issued patents or publications in technical journals.

Please airmail your resume to:

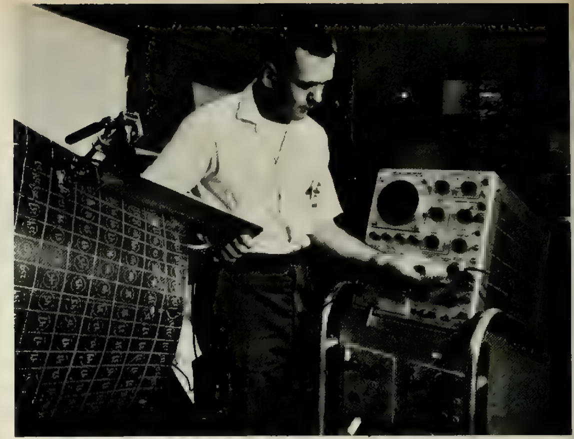
MR. ROBERT A. MARTIN
Head of Employment
Hughes Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 21, California

Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS

An equal opportunity employer.



TECHNICIAN calibrates ultrasonic test equipment for density measurements on an ablative heat shield for Minuteman re-entry.

NDT. The key is in selecting the correct combination of tests. "If you want to measure a list of properties for a design model, the first step is to translate the list of properties to a list of dependent material variables. The next step is to determine what kind of energy to use."

The target is a quantitative correlation. Test methods are based on the physics of interaction between the material and the energy forms used in nondestructive testing.

The results are plotted against destructive test information and the whole approach is an attempt to find what kind of NDT for what kind of variable for what kind of material.

The multiple prescription approach pays off, says Hastings. For instance, many materials are anisotropic and certain NDT approaches do not "see" this characteristic. But others do, and the choice of tests in the combination method covers anisotropic materials.

Hastings says that since NDT by its nature does not affect the material itself, it can be a highly useful tool in non-disruptive testing. Such tests can be superimposed on a destructive test to provide additional data while not interfering with the destructive test.

This approach aids in understanding the behavior of a given material in a dynamic situation such as ablation testing. If a specimen is being destructively tested in a simulated ablation environment, the NDT portion may be able to detect the exact cycle in which a crack started.

- **Intelligent choices**—The selection of influencing variables is a product of both experience in NDT and a working knowledge of the material under investigation.

For instance, the density of graphite is influenced by its porosity, flaw content and composition and purity. In addition, says Hastings, most materials used in missile/space applications are not homogenous. Even bulk graphite can be said to be a mixture of carbon and air. This inhomogeniety poses a danger in the sampling method adopted. Hastings says random sampling is not usefully applicable to composites. In the case of graphite, the effect of entrapped air on the fundamental properties of the material must be adequately known.

After recognizing the critical variables with regard to density, the list of variables can be extended in the example. For the property of oxidation and erosion resistance, the influencing variables are density/porosity, composition and purity, crystal structure, flaw content and anisotropy.

The matching variables for thermal shock susceptibility are elasticity, density/porosity, composition and purity, crystal structure, flaw content and anisotropy.

The last step is to show a correlation between the variables examined and the operational behavior of the material in its end application.

- **Equipment limited**—Hastings says Avco is not out to build an NDT equipment museum. He thinks the knowledge of the energy interactions is much more important. The Avco approach is to start with the physical principles involved and initially establish a route to valid information before concentrating on any specific NDT equipment.

Graphite and similar materials are relatively simple to handle from an NDT point of view. This is because they are brittle. The problem with the other great area of materials is plasticity (permanent deformation preceding failure.) Avco has another contract with the Air Force Materials Lab aimed at applying NDT to plastics.

In this area, Avco is defining properties and establishing the influencing variables in carefully selected materials representative of the whole field of structural plastics under another RT&D contract.

Both thermosetting and non-thermo-

Cubic SECOR pinpoints it...nothing else can!

The ability of Cubic's SECOR to fix exact locations in space is unequaled. Where other systems only come close, SECOR, the world's most precise satellite tracking system, determines space vehicle coordinates with *pinpoint* accuracy.

Operational concept...

The heart of SECOR is a miniature 7-lb Cubic transponder. Carried in the satellite, this instrument acts as receiver-transmitter to three Cubic-built portable ground stations. These stations, located at known points on earth, make approximately 29,000 measurements or "ranges" during a typical six minute satellite pass. By using simple trilateration, SECOR does its work.

Speed with economy...

In tracking, SECOR saves valuable time and eliminates errors. Unlike photographic and Doppler systems, it collects data and gives readings simultaneously . . . without delay. Since its initial use during Atlantic Missile Range tests, the SECOR system has proved itself to be more accurate than costly radar systems.

Varied applications...

Currently the U.S. Army is using the all-weather SECOR system to plot and measure the earth with amazing speed and surveying accuracy.

Because of this accuracy, SECOR is an ideal system for range instrumentation or guidance.

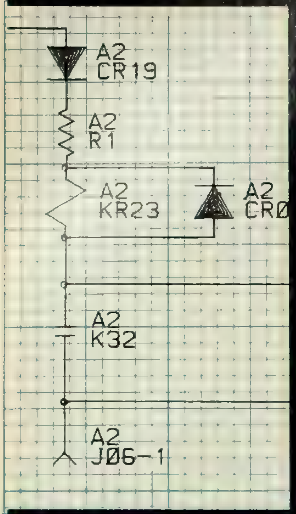
In addition to guidance evaluation and ground charting, another important SECOR application is the precise instrumentation of satellite interception or rendezvous.

The implications of SECOR are important in all future measurement of earth and space. It will play a growing role in space and defense programs requiring extremely accurate location of objects.

SECOR is a product of Cubic Corporation, leader in the field of electronic measuring systems. For additional information, write: Chief Scientist, Cubic Corporation, Dept. D-119, San Diego, Calif. 92123.

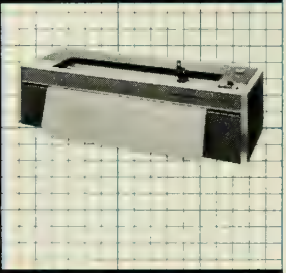
CUBIC
CORPORATION
SAN DIEGO, CALIFORNIA 92123
SYSTEMS DIVISION

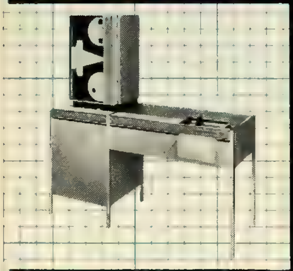
Circle No. 8 on Subscriber Service Card



DIGITAL PLOTTING *Is The Difference*

Benson-Lehner offers for the first time a 30-in. incremental plotter for on line operation for less than it would cost for a card input plotting system (under 10 K).





There is a great deal of difference in digital plotting when you consider the following advantages:
√ higher degree of accuracy
√ wider range of flexibility
√ compatible with all digital computers
√ capital outlay is drastically reduced

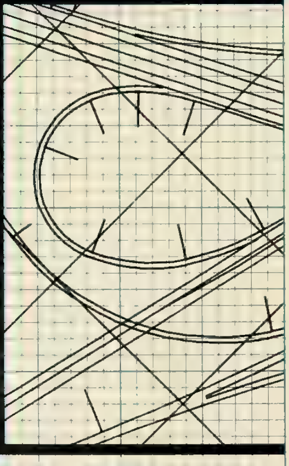
FEATURES

High speed (300 steps/sec.)
High resolution (.005")
120 ft. paper roll capability*

* 30 in. plotting paper is available with any desired preprinted grid, or, if more economical, 12 in. plotting paper can also be used.

Many computer sub-routines are available in our library for your use. Programming assistance is readily available.

Our warranty service is backed by the nation's largest field service organization specializing in computer graphic equipment.



benson lehner
14761 Califa Street, Van Nuys, California

Circle No. 9 on Subscriber Service Card

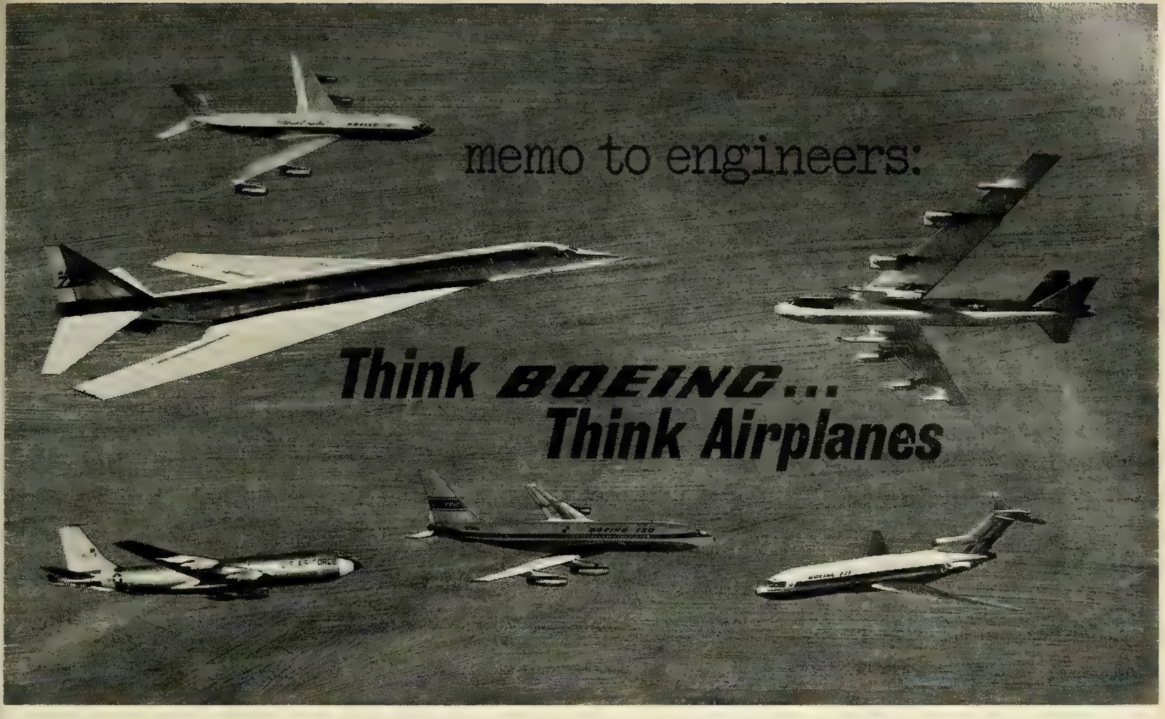
NONDESTRUCTIVE TEST PARAMETERS—MATERIAL INTERACTION

NDT Technique	Interaction	Related Material Variables
SONICS		
A. Ultrasonics (above 20 kc) pulsed and/or continuous wave		
1) Velocity measurements	Stress wave propagation	Elasticity Density/porosity Crystal structure Grain size Composition & purity Anisotropy
2) Attenuation measurement	a. Energy scattering	Elasticity Porosity Crystal structure Grain size Flaw content Anisotropy
	b. Energy absorption	Elasticity Density Crystal structure Composition & purity Anisotropy
3) Flaw detection	Reflection at an acoustical impedance mismatch	Elasticity Density Flaw content Anisotropy
4) Thickness resonance	Stress wave propagation	Elasticity Density/porosity Crystal structure Grain size Composition & purity Flaw content Anisotropy
B. Vibration analysis (up to 20 kc) shock and/or continuous excitation note: freq. range limited to 20 kc; higher freq. may be considered an extrapolation of the technique	Damping resonance	Elasticity Density/porosity Crystal structure Grain size Composition & purity Flaw content Anisotropy
PENETRATING RADIATION		
A. Radiography (X or gamma rays)	Absorption/scattering	Density/porosity Crystal structure Composition & purity Flaw content
B. Radiometry (X or gamma rays)	Absorption/scattering	
ELECTRICAL		
A. Resistivity (d.c.)	Resistance to current flow	Porosity Crystal structure Composition & purity Flaw content Anisotropy
B. Conductivity (a.c.) (eddy currents)	Resistance to eddy currents	
THERMAL		
A. Infrared heat-scan (transient & steady state) **B. Thermal comparator**	Heat absorptivity Diffusion Velocity of heat pulse transmission Radiation (emissivity) Conductivity	Density/porosity Crystal structure Composition & purity Flaw content Anisotropy

setting plastics are covered. The objectives include determining basic variables in the two major classifications and then finding out what kind of variable they are. Again there will be an effort to correlate NDT with destructive test information. One objective is to be able to fully test a piece without destroying it, since there are many components that demand exactly this in a practical sense.

Another problem with plastics is in determining what happens between fabrication and end use. Hastings says there are all kinds of degradative influences at work that NDT might not be able to detect.

While the emphasis at Avco is in bringing NDT upstream in the design process, there is an equal emphasis on the downstream side of the problem. Hastings and his experts are just as interested in getting NDT out of the lab into quality control functions on a production line—production in the missile/space sense where there are only a handful of end items. ■



ENGINEERS ARE NEEDED in the following assignments to carry on the nearly half century Boeing tradition of designing tomorrow's airplanes today for military and commercial use. These requirements are in Boeing Airplane Divisions with locations at Wichita, Kansas and Renton, Washington.

FLIGHT CONTROL SYSTEMS — Establish design criteria and specifications for flight control systems, subsystems and components; selection of components; and monitoring of flight test.

CONTROL DYNAMICS — Servo control analysis to develop automatic terrain-following concepts, load-alleviating stability augmentation systems and automatic flight control systems. Experience in analog computer programming and familiarity with digital computer techniques.

AERODYNAMICS — Perform analysis of aerodynamic characteristics effected by airplane control systems and stability augmentation systems. Experience in systems analysis and working knowledge of analog computers.

STRUCTURAL DYNAMICS — Analysis of complex structure virbration, airframe loads and response, and application of probability theory to structural design criteria.

LOADS ANALYSIS — Perform aeroelastic loads analysis, coordinate loads testing and establish requirements for extensive design loads investigations.

STRESS ANALYSIS — Perform research of load-paths and strength characteristics of aircraft structure. Perform strength checks and formal stress analysis. Establish programs and document analysis data.

HYDRAULIC SYSTEMS — Analysis, testing and design of hydraulic systems. Experience with system pumping, control components, and heat transfer of high pressure systems (knowledge of current techniques used in hydraulic servo valves for powered flight controls).

ENVIRONMENTAL CONTROL -- Heat transfer analysis with application to air cycle conditioning of jet aircraft. Emphasis upon avionic equipment conditioning to develop new environmental conditioning concepts.

ANTENNA SYSTEMS — Design, performance, evaluation, and analysis of radome, antenna, and RF transmission systems. Experience in antenna, radome, or wave propagation.

NAVIGATION AND GUIDANCE SYSTEMS — Analysis of electromechanical systems and derivation of system transfer functions to quantitatively predict system performance. Experience in feedback control systems.

OTHER POSITIONS AVAILABLE IN: • FLIGHT TEST OPERATIONS • FLIGHT TEST INSTRUMENTATION • FLIGHT TEST DATA PROCESSING • ELECTRONIC COUNTERMEASURES • HUMAN FACTORS • TECHNICAL PUBLICATIONS • WEIGHTS • FATIGUE ANALYSIS • RADAR TECHNOLOGY • WEAPONS DELIVERY SYSTEMS • ELECTRICAL SYSTEMS • OPERATIONS RESEARCH •

All positions require a B. S. or advanced degree in engineering, physics or mathematics. You are invited to send your resumè or letter indicating your specific area of interest to either:

Mr. Tom Sheppard, Dept. BAV
Boeing Airplane Division
P. O. Box 707
Renton, Washington 98055

Mr. Gerald Caywood, Dept. BAV
Boeing Airplane Division
4300 E. MacArthur Road
Wichita, Kansas 67210

BOEING
AIRPLANE DIVISIONS
RENTON, WASHINGTON ■ WICHITA, KANSAS

An Equal Opportunity Employer

Biosatellite Hardware Nearly Ready

Life support system will be first built by U.S. with mixed oxygen/nitrogen atmosphere; a look at plans for three missions

by Heather M. David

King of Prussia, Pa.—Breadboard hardware for the life support system and experiment packages of NASA's *Biosatellite* will be completed at General Electric's Missile and Space Division sometime next month.

The life support system will be unique in that *Biosatellite* will be the first U.S. spacecraft to carry a mixed oxygen/nitrogen atmosphere at sea-level pressure. All others use a 100%-oxygen, 5-psi gas environment—which many biologists claim might interfere with the research results of the *Biosatellite* mission.

GE's Gordon Fogel says engineering life support for the three *Biosatellite* missions has actually resulted in the design of two systems, one of which has two kinds of modifications. Thus, although there is only one exterior *Biosatellite* design, GE engineers working on the interior design must plan in terms of three satellites.

In all three versions, the gas management system, which has been contracted to Hamilton Standard Div., United Aircraft Corp., for detail design, is contained in the spacecraft adapter section. In all, temperature is maintained at 75 ± 5°F, and humidity at 40-70% RH. For the first mission, however, it will contain only 3,500-psi containers of conditioned air (premixed oxygen and nitrogen), the two blowers, the heat exchanger system and condensate collector. For the latter two missions, there are supercritical oxygen and nitrogen containers, with a monitoring system.

BIOSATELLITE MISSION EXPERIMENTS

THREE-DAY ORBIT, RADIATION/WEIGHTLESSNESS

Induction in Lysogenic E. Coli Bacteria	Dr. R. H. T. Mattoni, North American Aviation Drs. W. T. Romig, W. T. Ebersold, U. of Calif.
Mutations and Cellular Inactivation of Neurospora	Dr. F. J. DeSerres, Oak Ridge Nat'l Lab.
Mutation of Tradescantia	Drs. A. H. Sparrow, L. A. Schairer, Brookhaven
Mutagenic Effectiveness on Habrobracon	Dr. R. C. von Borstel, Oak Ridge
Larvae and Adult Male Drosophila	Dr. I. I. Oster, Institute for Cancer Research
Embryonic Development of Tribolium	Dr. J. V. Slater, U. of Calif.
Reproductive Cells of Adult Female Drosophila	Drs. E. Altenburg, L. Browning, Texas Medical Center

THREE-DAY ORBIT, GENERAL BIOLOGY/WEIGHTLESSNESS

Liminal Angle of the Pepper Plant	Dr. J. C. Finn, Jr., North American Aviation
Germination and Orientation of Roots and Shoots of Wheat	Dr. C. J. Lyon, Dartmouth
Orientation of Roots and Shoots of Wheat	Drs. H. M. Conrad, S. P. Johnson, North American Aviation
Root and Shoot Orientation and Growth of Wheat Seedlings	Drs. S. W. Gray, B. F. Edwards, Emory U.
Nutrition and Growth in Pelomyxa Carolinensis	Drs. R. W. Price, Colorado State U., D. E. Ekberg, General Electric
Fertilization and Development of Sea Urchin Eggs	Dr. R. S. Young, Ames Research Center
Fertilization and Development of Frog Eggs	Dr. R. S. Young, Ames Research Center

TWENTY-ONE-DAY ORBIT, GENERAL BIOLOGY/WEIGHTLESSNESS AND BIORHYTHMS

Isolated Human Cells	Dr. P. O'B. Montgomery, U. of Tex.
Plant Morphogenesis of Arabidopsis	Drs. A. H. Brown, U. of Pa., A. O. Dahl, U. of Minn.
Body Composition of the Rat	Dr. G. C. Pitts, U. of Va.
Circadian Metabolic Rhythms in the Rat	Dr. F. Halberg, U. of Minn.

THIRTY-DAY ORBIT, LONG-TERM WEIGHTLESSNESS

Neurological, Metabolic, and Cardiovascular Functions in the Primate	Drs. W. R. Adey, UCLA, and P. J. Meehan, USC
Mineral Loss of Bone in the Primate	Dr. P. B. Mack, Texas Women's Univ.

- **Three-day mission**—There is a total of 14 experiments. Half are simple weightlessness experiments, the others concern synergistic effects of weightlessness and radiation.

Since the organisms consume virtually no oxygen and produce no wastes, design of this system is relatively simple. Most of the experiments are encased in clear containers. GE is considering plexiglass or Lexon, a GE plastic.

The flight will, however, give the life support designers a chance to test some of their equipment—such as the blowers, heat exchanger system and pressure sensors.

The radiation experiments in the three-day mission will be exposed to a source of gamma radiation, about 1.0 curie of Strontium 85. This will yield from 300-6,000 roentgens of radiation in three days. Background radiation at the orbital altitude, which will be well below 200 miles at all times should be less than one roentgen.

The experiments will be exposed to radiation only during the weightless phase of the flight. After orbital injection, a shutter will open to expose the radiation source. The remaining seven experiments, which study various aspects of weightlessness in general biology, are placed forward of a shield.

One of the unique problems of integrating all these experiments into the same life support cycle is the fact that the frog egg experiment must be kept at a low temperature, or the eggs will begin development. To insure that this development does not begin until after launch, an active cooling system was designed for control during countdown.

Batteries are the power source on this mission. The GE fuel cell will be used on the latter two missions.

According to NASA's Dr. Dale Jenkins, both flight and ground controls will be used. In addition, all effects of

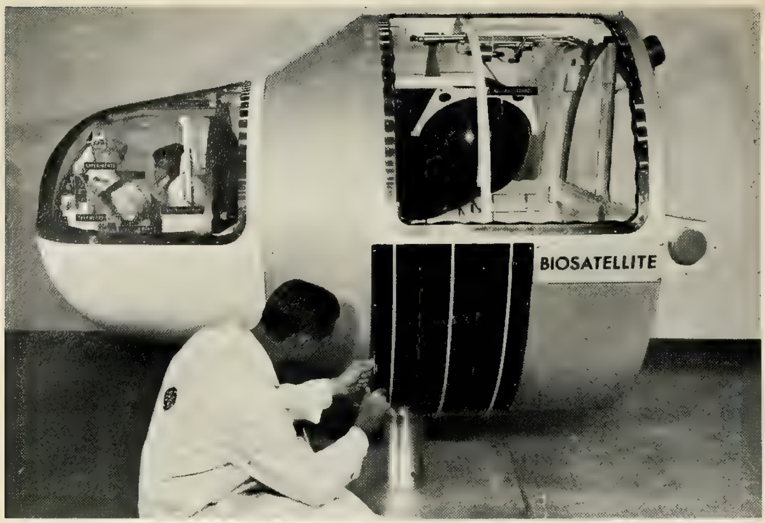
Circle No. 10 on Subscriber Service Card

available now!

Titan III, the U.S. Air Force's standard space launch system delivering nearly 2.5-million pounds of thrust . . . handling payloads from over ten tons for a 200-mile earth orbit to two-and-one-half tons for a moon shot . . . mission flexibility ranging from the orbiting of multiple satellites to boosting a complete manned laboratory into orbit. Cost effective. Man rated. Reliable. Even while it is still in R&D, Titan III is launching functional payloads—36 assigned to date.

Got a space mission? Get the facts on Titan III. Write on your letterhead to Dept. RC-400, Martin Company, Friendship International Airport 40, Maryland.

MARTIN



FIRST PHOTO of new, foreshortened configuration of Biosatellite, developed by GE for NASA. Spacecraft is both wider and shorter than original design, because of elimination of one stage of Thrust-Augmented Delta booster.

dynamic factors of the flight profile are being studied with and without a radiation source.

● **21-day mission**—The second mission, aimed at studying the effect of spaceflight on diurnal rhythms, poses some difficult problems. Eight rats will be orbited for three weeks, and two experiments will be performed upon them. By use of temperature transducers and feeding monitors, researchers hope to discover if the normal patterns are upset.

Eight cages for the rats are arranged in a cylindrical pattern, with the food supply in the center. All rats feed off the same tube, with steel nipples extending into each cage. Back-contamination is prevented through valves in each nipple.

There are 11 pressurized food containers. To prevent spoilage, each will be open only for two days.

Each cage is magnetically and electrically isolated, so that the sensors can operate independently. An implated temperature sensor transmits an RF signal, which can be picked up by one of three antennas in each cage, placed on the sides and top. From the signal, researchers can determine what position each rat is in. Signals also report on the frequency of feeding.

One of the problems now being considered is whether the rats' teeth will grow too long, because of lack of anything to chew for 21 days, and render it impossible for them to feed at the nipples.

Maintaining the rats has necessitated design of extra life support equipment within the capsule. Air blowers are used to blow waste downward into a storage area of 33 cubic inches for each cage. Output of only 2 cc's for the three-week period is normal.

Trace contaminants will be taken care of by a bed of amberlyst resin, with the biggest problem being ammonia. Buildup of methane is not expected. Any carbon monoxide produced by the rats will pass over a bed of a dessicant molecular seive, and then into a Hopcalite canister. In this canister, it will be oxidized to carbon dioxide, and pumped into the main-capsule gas-management system. Lithium hydroxide will be used to remove carbon dioxide in all three capsules.

Oxygen for the 21- and 30-day missions is supercritical and probably will be stored with fuel-cell oxygen. Common storage also will be used for nitrogen for the gas management system and the spacecraft attitude-control system. The air blowers, also in the adapter system, keep an airflow of from 8-9 cfm in the cabin. Also located there is a condensate collector, which vents its water from the environmental gas stream to space. Water for drinking is provided by the fuel cell, which is similar to the one designed for the *Gemini* capsule by General Electric.

One of the problems faced by designers is the quite considerable loss of heat in the parachute descent. The capsule must be heated through the water supply during this period. Oxygen for the recovery phase is provided through a bottle in the capsule.

There will be two other experiments in the 21-day mission, dealing with longer-term weightlessness effects.

● **31-day mission**—The only subject expected to be orbited in the long-term weightlessness mission is a 14-16-lb. primate. However, several concurrent experiments are to be performed on the animal.

The primate will have deep brain probes surgically implanted for neurological studies, as well as catheters for cardiovascular studies. It will be photographed during the flight. In addition, it will have certain psychomotor tasks to perform, and a record will be made of calcium loss from the bones using a bone densitometer X-ray before and after the flight.

The primate will be restrained in a web-like hammock, with only its forearms protruding. A metal cover will keep it from using its legs to grasp wires or other parts of the capsule.

A major concern in the primate capsule is waste management. The monkey will have a metal plate screwed to the bottom of the pelvic bone sometime before launch; during launch the plate will be connected to the waste management system. An air blower forces the waste material to a storage hatch, which has a capacity of 200 cubic inches, double what is expected. A disinfectant will be sprayed on the primate from time to time.

Method of collecting liquid wastes has not yet been determined, but it may take the form of an implanted catheter. *Biosatellite* requirements are to measure quantity, rate and pH of waste material.

Food will be available to the primate on a special device comprised of eight drums containing tapes, on which food pellets are fixed. When a lever is pulled, the tape moves into a stripper, and the pellet comes off. The monkey pellets will provide 2.3 grams of food each, containing 7.5 Kcal/pellet. They are manufactured by Ciba Pharmaceutical Company.

The monkey is allowed food for normal feeding, and at certain times, for reward for psychomotor task performance. There are a total of 225 pellets on each of the eight drums—the multiple arrangement being designed so that if one drum malfunctions the animal can get enough food from the others to subsist. The feeder was designed by Inventive Engineers, Inc.

Water is obtained through a nipple. Thirty cc/hour is available in the 12-hour day. The monkey can obtain that maximum at night, if this is deemed necessary.

During the recovery operation, there is a special storage vat for water. It contains 100 cc's, and is available on demand.

● **Testing program**—GE will deliver two sets of hardware to NASA and two to each experimenter, for environmental and animal testing. Hardware will also be tested at GE for such factors as shock, vibration and toxicity of materials. ■

Experts at Odds over Mars Goals

AAS meeting hears Voyager praised, but life detection experiment schedule criticized; little agreement on photos needed for lander

by Rex Pay

DENVER, COLO.—A first attempt to detect life on Mars with a simple experiment in a 1971 *Voyager* lander looks likely, but both earlier and later attempts are being urged.

Mars fly-by missions in 1969 or 1971, with return of the spacecraft to Earth, are also being proposed as the best means of getting high-resoluton pictures of the Martian surface.

A wide spectrum of opinions on how Mars should be explored came out of the Symposium on Unmanned Exploration of the Solar System presented here by the American Astronautical Society.

So diverse were the views presented by spacecraft engineers, astronomers, and biologists that in summing up a panel discussion on the subject, chairman Richard G. Fleddermann of the Martin Company concluded "something is drastically wrong with the unmanned exploration of the solar system. There has not been a firm welding or melding of engineering and science."

However, in the furor, the *Voyager* spacecraft came out with honors. The main differences were over mission schedules.

According to Homer E. Newell, Associate Administrator for Space Science and Applications, a *Voyager* landing capsule in 1971 would primarily be intended to make physical measurements on the Martian atmosphere and surface. But at the same time, he said, a simple bioscience experiment is likely. He believes that initial experiments may have to be confined to small capsules that can be sterilized, if the problems of sterilizing large capsules appear to be too great.

Temple Neumann, Automated Biological Laboratory program engineer with the Aeronutronic Division of Philco, said that an ABL launched by a *Saturn IB* could be hard-landed in 1971 as part of a *Voyager* mission (complete with fly-by or orbiter) without previous detailed mapping of the planet's surface. He said a provisional set of biological experments had been selected to enable iteration of ABL mission parameters.

● **Schedule urgency**—The chief arguments against the *Voyager* schedule came from Gilbert V. Levin of Hazleton Laboratories. He said that although we insist that Mars should not be contaminated by terrestrial life before we search for Martian life, we fail to recognize that this is tantamount to saying that the U.S. must get there first, because the U.S. appears to be the only nation willing and able to sterilize its spacecraft.

Neumann agreed, saying that no sterilization program comparable to that of NASA was in evidence elsewhere in the world. "If the planetary biological exploration task is to be performed in a sound scientific manner, the United States must do it—first," he said.

Levin said it was highly unlikely that the U.S. would get to Mars first, because we were foregoing 50% of our opportunities. He said that the $1.5 to $2-billion funding forecast for *Voyager* should not be put into one complex spacecraft but into 10 to 15 smaller spacecraft, costing $150 to $200 million each. "I am all for *Voyager*", he said, "but an initial step in the *Voyager* program should be some early landers at the earliest opportunities. We should go ahead and devote efforts to develop a program to land on Mars in 1969."

The disastrous effect that an unsterilized spacecraft could have on Mars was emphasized by Lawrence B. Hall, NASA Special Assistant for Planetary Quarantine. He said that terrestrial life has multiplied in simulated Martian environments. If a single micro-organism should land on Mars and have a replication time of 30 days, it could grow to the bacterial population of Earth in eight years. This could not only compete with Martian life but could result in drastic changes in the geochemical and atmospheric characteristics of the planet, he said.

As the current *Voyager* schedule stands, the first attempt to find out what sort of life exists on Mars will not take place until 1974. Levin expressed the fear that Russian spacecraft would start to land about nine years before this.

Gerald A. Soffen, Jet Propulsion Laboratory, said that since the decision between *Mariner* landers and *Voyager* missions has not been made yet, scientific experimenters have to think in terms both of small payloads (tens of pounds) and large ones (hundreds of pounds). Numerous small missions would provide a good opportunity to perform experiments in different locations and during different planetary seasons. Larger payloads place much greater responsibility on a few missions, which would have to be in the right place at the right time.

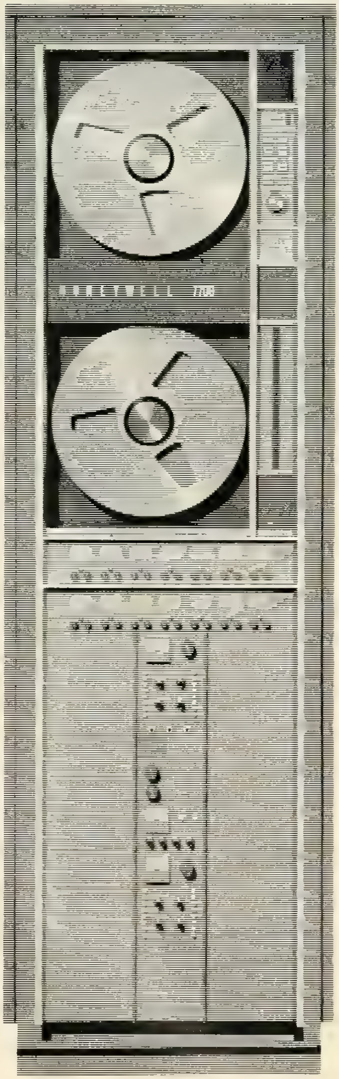
This last problem was emphasized by Bruce C. Murray, California Institute of Technology, who said that finding the right location, getting there, and interpreting the biological experiment results in a way that would indicate definitively whether life was or was not present would call for at least 100 times more photography than was currently assumed.

● **More photos needed?**—He said that for interpreting pictures of Mars a complete set of scales of resolution is needed. Unless you go down in staged steps of resoluton (as in the *Ranger* series) high resolution does not do any good. Also he emphasized that the difference between nominal resolution and what can be actually interpreted on an unknown landscape involves a scale factor of five or ten. To interpret features 10 meters across calls for one-meter resolution (the *Ranger* pictures differ because small circular objects at the limit of resolution are assumed to be craters).

He said atmospheric effects, color, seasonal changes, and the large number of locations of interest will make Martian pictures 10 to 50 times more difficult to interpret than lunar pictures. While lunar mapping for *Apollo* landing involves 10^{11} to 10^{12} bits of information, at least 10 times this amount will be needed to soft-land a complex spacecraft on Mars, said Murray.

The Honeywell 7700 introduces these four significant advances in analog magnetic tape instrumentation:

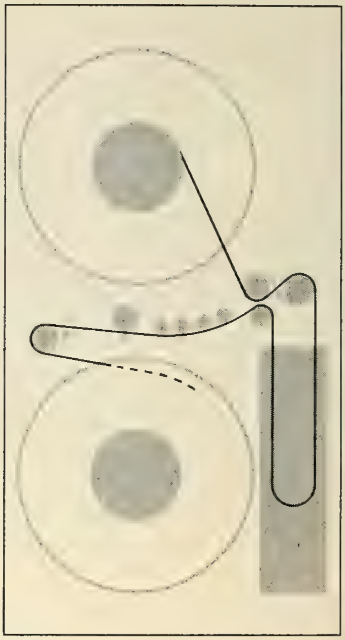
TIME DISPLACEMENT ERROR—Timing errors between record and playback can originate in dimensional changes in the tape caused by temperature, humidity and tension variations as well as differences in tape speed between record and playback. These effects have been minimized through use of a tape-controlled servo on the playback mode. Until now, however, high inertia systems could only reduce instantaneous timing errors to about 1 millisecond. The new Honeywell 7700 low inertia, high-response servo reduces this error to 1 *microsecond* at 120 inches per second.



FLUTTER—In the past, flutter has been reduced by use of high inertia drive systems which lose their effectiveness at low frequencies and low speeds. The high-response servo in the Honeywell 7700 virtually eliminates flutter below 100 cps and holds wideband flutter below 0.25% from DC to 10KC at 60 ips.

DYNAMIC SKEW—If data on two or more channels are to be compared, it is essential that varying time differences between channels caused by dynamic skewing of the tape be reduced. The use of vacuum column isolation and a 13-inch edge guide ahead of the record-playback heads reduces dynamic skew in the Honeywell 7700 to approximately one-third of that in state-of-the art analog systems.

SIGNAL/NOISE RATIO—Noise caused by electronics, tape and the tape transport can mask small amplitude data changes. Efforts to improve linearity, drift and other parameters are fruitless if a high percentage of noise is present. The Honeywell 7700 will produce signal-to-noise ratios as great as 48 to 52 db rms. This is a 2-to-1 improvement over the 40 to 44 db noise found in other FM systems.



The Honeywell 7700 is an 80 KC FM-640 KC Direct system built specifically to preserve the quality of your most critical data.

For complete specifications, call a scientific field representative at your nearest Honeywell office, or write Mail Station 402, Honeywell, Denver Div., Denver, Colo. 80217. In Canada: Toronto 17, Ontario.

DATA ACQUISITION SYSTEMS

Honeywell

Circle No. 13 on Subscriber Service Card

Current programs, however, are likely to yield only 10^9 to 10^{10} bits of information on Mars by 1971, so "we will be trying to deploy landers with 100 times less information than we need," said Murray.

● **Data return a problem**—Dr. Philip Eckman, Advanced Technical Studies Group, JPL, said he was not in complete agreement with the need for such high amounts of information, but because other people agreed with Murray, he had looked at alternative ways of obtaining such data. Assuming this amount of information could be stored on film in a spacecraft, Eckman said current projections of communication channel capacity (spacecraft transmitter 100 watts and 8-ft. antenna, three 210-ft. DSIF antennas) showed that spacecraft near Mars could not return this amount of data even in a year.

One way to get the data back, said Eckman, was to use an *Atlas/Centaur* to put a 1,200 to 1,500-lb. spacecraft on a 1,110-day mission to Mars and back. The spacecraft would be able to playback a 2 X 10^{12} bits of data during the week it was within 100,000 km of Earth, which would be close to Murray's requirement.

● **Earth-return missions**—Eckman said that Earth-based radio guidance was probably adequate for the Earth-return mission. The duration of the mission could be reduced to 470 days by use of a rocket-impulse at Mars. Eckman said that if Murray's assessment is correct, more effort should probably be put into systems and missions analysis to examine possible solutions.

The value of Earth-return missions was also stressed by Robert L. Sohn, TRW Space Technology Laboratories, who said that they could be flown to within a few hundred kilometers of the Martian surface. *Voyager* orbiters are usually limited to a minimum altitude of 1,000 km, to give them a 50-year life in orbit, and are likely therefore to yield 200-meter resolution in mapping missions. A low flyby could raise the resolution to 10-20 meters, using image motion compensation.

Sohn said that round-trip missions and multi-planet round trips should be given much greater consideration. He said DSIF was an incredibly precise source of spacecraft guidance, capable of accuracies better than 1 ft. per sec. in velocity and 100 ft. in range, at ranges up to 100 million miles. Operating in conjunction with high-accuracy sensors on the spacecraft, the DSIF will be able to guide the spacecraft on round trips, said Sohn.

He suggested that an 800-lb. spacecraft could make a flyby of Mars, using the Venus swingby technique (M/R, Dec. 14, 1964, p. 24) and return to Earth to enable recovery of a 50-lb. capsule. Use of swing-by techniques for round trips reduces Earth launch velocities to those of the favorable years and also reduces Earth re-entry velocities. Additional advantages are closer passage with Mars at encounter, and the opportunity to gather data on two planets.

Gerard de Vacouleurs of the University of Texas said that knowledge of Mars is still sketchy. He added that at the moment we see bright and dark regions that mean nothing to us. On the Moon we can see mountains: on Mars we have not yet crossed a certain resolution threshold that enables us to say what the patterns we see mean. He doubted that even pictures taken at a distance of a few thousand miles from Mars would resolve the problem of large land masses. "I firmly believe we should very carefully stop, look, and listen: we don't know about the surface", said Vacouleurs.

● **No consensus on required data**—Disagreement with Murray about the amount of data required before life detection experiments could be carried out came from a number of sources. Neumann thought that an ABL could be landed with a high probability of arrival, even with little more surface data than is currently available. Soffen said that some areas may be more infected with life than others and that choice of site and season may be extremely important. He pointed out that only a few hundred miles separate the fertile plains of the Congo from the Sahara Desert.

Elie A. Shneour, Stanford University, said that if life exists on one part of a planet, it is likely to be found over all of it, and is probably sufficiently abundant to be readily detectable. He said biological systems do not thrive in an ecological vacuum; they depend upon a variety of symbiotic relationships that preclude uniqueness.

● **Diverse opinions**—Views on how life detection should be attempted on Mars were represented at one extreme by Murray's view that a definitive attempt should be carefully planned. Richard Young, NASA Ames Research Center, agrees with this approach (M/R Jan. 18, p. 32). The opposite view was the broad-brush approach urged by Levin, who asked whether anyone thinks that even a 10,000-lb. spacecraft could carry out a definitive life experiment on Mars, when this could not even be carried out on Earth. He thought it might be unrealistic to expect an unambiguous answer and that we should go ahead with a sample experiment. Newell thought a simple attempt would be made at an early stage. Guido Munch, California Institute of Technology, said that he did not believe that science could be carefully planned. He believes scientific objectives in exploring the solar system should be made commensurate with spacecraft effort. He said that even the scientific work done at present is limited to what we can do rather than what we would like to do.

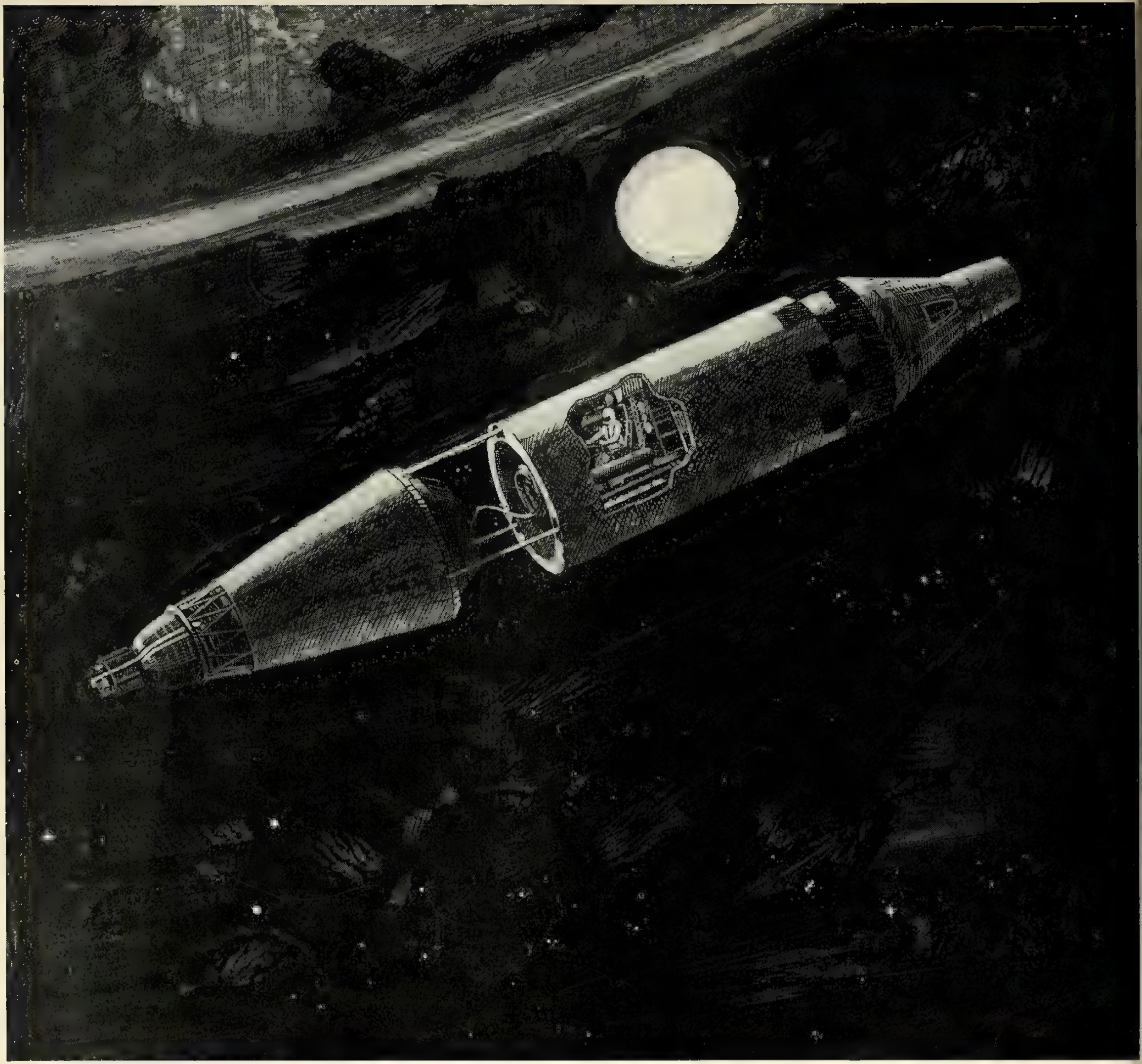
Neumann said that the most difficult problem in the design of the ABL was selecting the most meaningful characteristics of life. He said, however, that there was considerable value in use of integrated experiments, as they enabled a number of related tests to be made on the same sample. This would give much more information than if the same number of tests were carried out independently on separate samples.

● **More than one way**—Soffen said that the many concepts and breadboard instruments put forward for the detection of life showed that there was no single experiment that was the obvious choice for life detection. He suggested three main classes: the chemical-analytical, which seeks to identify life by its unique chemistry; the morphological, which seeks to find life by its characteristic form; and the functional, which detects life by its ability to change its environment and reproduce itself. Soffen predicted that mission constraints for early landers would preclude any capability of extensive command from Earth, so experiments would have to operate automatically.

He said that the Gulliver radioisotopic growth-metabolism experiment involved at least 12 automatic steps in sequence (and in some cases timed). While component failure has occurred during some tests, said Soffen, this instrument has compiled a remarkable record of success for its level of complexity in the few times it has been tested.

Shneour said that he could not say whether it was possible to draw up a set of experiments that would definitively search for life. He said that although so-called life detection devices had been tested on Earth with limited success, "there can be no question that until instruments can demonstrate the variegated existence of life on Earth by remote means with a very high level of confidence and reliability, it will be premature to claim that we have a basis for undertaking a search for extraterrestrial life." He said it is most likely that detection of extraterrestrial life can be accomplished by successive approximations, using a wide array of coherently integrated measurements.

Shneour also suggested that discovery of any form of extraterrestrial life will be tantamount to a basic determination of the nature of *all* life on that planet. Although this will not give an insight into the whole ecology it will drastically simplify all further investigations of that planetary life. ■



SURVIVAL UNIT

It is a SNAP reactor system—source of long-lived electric power for life support and environment control. It will supply astronauts with heat against the cold. Purify the air they breathe. Give them light amidst blackness.

North American Aviation / Atomics International Division is developing SNAP reactors for reliable, long-lived power in space vehicles, manned space stations, satellites, and manned bases on the moon. In pioneering SNAP reactor systems for the Atomic Energy Commission, A.I. has reduced equipment as large as a house to the size of a five-gallon can.

Atomics International is one of seven divisions at North American Aviation—a corporation dedicated to advancing the frontiers of science in nuclear energy, electronics, rocketry, aviation, life sciences, and space flight.

North American Aviation

Atomics International, Autonetics, Columbus, Los Angeles, Rocketdyne, Science Center, Space & Information Systems

The Industry Week

New Activities

General Dynamics has re-consolidated its Convair and Astronautics divisions into one operating division that will continue under the Convair name. Both divisions are located in San Diego, Calif. The Astronautics Div. was founded in 1957 as a Convair off-shoot to develop, build and emplace the Atlas ICBM system. With that specific job accomplished, GD believes that "it is again practical to combine the effort of the two divisions to better meet present and future needs of the customers." . . . *FMC Corp., San Jose, Calif., has expanded its defense materiel activities into the fields of weapons and munitions with the formation of the Defense Technology Laboratories in Santa Clara, Calif. The new facilities will include a model and preproduction shop, explosive and weapon test facilities and equipment for casting and pressing explosives.* . . . Machtronics, Inc., has changed its name to MVR Corp. The Palo Alto, Calif., manufacturer of television tape recorders made the change to identify more closely with its products and to eliminate possible confusion with other companies with similar names. . . . *Houston Instruments Corp., Houston, has incorporated two of its operating divisions. Auto Data, Inc., San Diego, Calif., will continue marketing, manufacturing and engineering activities formerly conducted by Houston's Digital Voltmeter Div. Houston Omnigraphic Corp. has been established to design, manufacture and sell the HI line of recording instruments.*

Mergers and Acquisitions

Varian Associates, Palo Alto, Calif., has obtained the approval of LEL, Inc., stockholders in its bid to acquire that firm. LEL as a result becomes the LEL Div. of the Tube Group of Varian. The division will specialize in the development and production of microwave preamplifiers, mixers, IF amplifiers and other microwave components. . . . *Silicon Transistor Corp., Garden City, N.Y., has acquired most of the outstanding stock of Dynatran Electronics Corp. of Mineola, N.Y. Silicon Transistor manufactures power transistors and silicon-controlled rectifiers; Dynatran makes hign-power solid-state d.c. amplifiers and automatic test equipment and instrumentation for the evaluation of semiconductor devices and circuits. Simultaneously with the stock purchase, Silicon acquired all outstanding convertible debentures of Dynatran.* . . . Avco Corp., New York, has agreed to buy Bay State Abrasive Products Co.'s stock for $26 million in cash. Bay State, located in Westboro, Mass., produces bonded abrasives, diamond grinding wheels and related products. Avco president Kendrick R. Wilson, Jr., said the acquisition will provide his firm with "outstanding commercial products and an extensive marketing organization, which will be complemented by Avco's advanced capabilities in materials research and development." . . . *Schaevitz Engineering, Pennsauken, N.J., has acquired Control Logic, Inc., of Natick, Mass., in an exchange of shares. The acquired capabilities are said to complement those of other Schaevitz companies in the area of aerospace and industrial automation.* . . . Laboratory for Electronics, Inc., Waltham, Mass., has acquired a line of radiation detectors, including halogen quench, neutron and cosmic ray tubes, from Radiation Counter Laboratories, Inc., Skokie, Ill.

Missile/Space Facilities

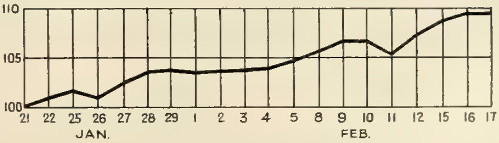
Electro-Optical Systems, Inc., Pasadena, Calif., has begun construction of a $5.4-million, 8-acre Aerospace Sciences and Engineering Center. The facility is intended to tie into an integrated complex the company's range of technological and systems efforts. The center, which will adjoin the present EOS Research Headquarters, will provide research, development, systems engineering and administrative facilities of approximately 410,000 sq. ft. . . . *ITT Federal Laboratories has announced plans to begin construction soon of a new microelectronics facility for assembly of high-density electronic equipment using a large percentage of semiconductor integrated-circuit devices. The facility will be used for the assembly, packaging and interconnection of a variety of microelectronic devices.*

Industry's Health Excellent: Harr

Aerospace Industry Association President Karl G. Harr, Jr., told the Detroit Economic Club last week that, despite recent reports to the contrary, the financial health of the aerospace industry is at an all-time high and that the industry will play a leading role in the future of the national economy. He warned against the tendency to project the future of the industry using economic criteria applicable to other industries. He stressed that the size and viability of the industry are not tied to defense and space programs alone. "They are tied, rather, to the total technological progress of the nation, meaning the application of advanced technology to whatever purposes may be desired," Harr said.

Missile/Space Stock Index

The Missile/Space Stock Index continued to climb to new levels as Viet Nam tension persisted. The New York Stock Exchange also revealed that the category in which these companies fall on the Exchange had a better than 18% increase in dividend payments last year over the previous year.



STOCK PRICES FURNISHED BY MERRILL LYNCH PIERCE FENNER AND SMITH

AIR FORCE

$8,052,000—**Lockheed Aircraft Corp.**, Sunnyvale, Calif., for launch services for *Agena-D* boosters.

$2,000,000—**Unitec Corp.**, Timonium, Md., for calibration services at White Sands Missile Range, N.M.

$1,108,486—**International Telephone and Telegraph Corp.**, Paramus, N.J., for spare parts for electronic data systems.

$247,287—**Melpar, Inc.**, Falls Church, Va., for research, antenna pointing and Doppler prediction computer complex.

$243,868—**Curtiss-Wright Corp.**, Wright Aeronautical Div., Wood Ridge, N.J., for feasibility demonstration and development of a large impulse controllable solid-rocket attitude-control motor.

$197,466—**Shell Development Corp.**, Emeryville, Calif., for development of a high-energy solid oxidizer binder.

$59,106—**Bell Aerospace Corp.**, Bell Aerosystems Co., Buffalo, N.Y., for research on thermal radiation from the combustion products of high-energy propellants.

$40,750—**Martin Marietta Corp.**, Denver, Div., Denver, Colo., for engineering support for the *Titan I* weapon system.

ARMY

$17,334,517—**Global Associates**, Oakland, Calif., for support services at the Kwajalein missile test site in the Pacific.

$7,500,000—**Sylvania Electric Products, Inc.**, New York City, for continued work on classified electronic equipment at Needham Heights, Mass.

$4,353,000—**Chaney and James Construction Co., Inc.**, Richardson, Tex., for the construction of two service bulidings at the NASA Mississippi Test Facility, one for *S-II* stages of the *Saturn* rocket and the other for cryogenic barges.

$3,224,815—**Warrior Constructors, Inc.**, Houston, for erection of an engineering facility at the Manned Spacecraft Center.

$902,713—**Northrop Corp.**, Newbury Park, Calif., for guided missile targets.

$345,600—**Philco Corp.**, Aeronutronic Div., Newport Beach, Calif., for advanced tube research program.

$315,246—**Arnold M. Diamond, Inc.**, Great Neck, N.Y., for vehicle unloading dock and area, Launch Complex 39, NASA Merritt Island Launch Area, Fla.

$296,517—**Raytheon Co.**, Andover, Mass., for engineering services for the *Hawk* missile system.

$119,837—**Stanford Research Institute**, Menlo Park, Calif., for study for *Nike-X* anti-missile missile system.

$100,279—**Fruehauf Corp.**, Fullerton, Calif., for *Sergeant* ground handling equipment.

NAVY

$10,257,755—**Johns Hopkins University**, Applied Physics Laboratory, Silver Spring, Md., for continued research and development work on missile programs.

$3,620,829—**North American Aviation, Inc.**, Anaheim, Calif., for two contracts to work on an inertial navigation system for *Polaris* submarines.

$1,251,406—**Raytheon Co.**, Wayland, Mass., supplemental contract to make modification kits for *Tartar* missile radar sets.

$700,000—**Ryan Aeronautical Co.**, San Diego, Calif., for production of Doppler automatic radar navigational equipment for ASW helicopters.

$475,000—**Booz Allen Applied Research, Inc.**, Chicago, for exploratory research, investigative studies and compilation and assignment of supporting information relating to the overall Navy astronautics program.

$219,890—**Aircraft Armaments, Inc.**, Cockeysville, Md., for production of a number of radar test sets, AN/SPM-17, for determining the compatibility between *Terrier* guidance radars and the *Terrier* missile.

NASA

$9,187,000—**Pacific Crane & Rigging Co.**, Paramount, Calif., for two contracts to install hardware aboard the first three mobile missile launchers being built at the Kennedy Space Center's Merritt Island facility, Fla.

$762,262—**Wolf Research & Development Corp.**, West Concord, Mass., for space science data center equipment.

$600,000—**Mesa Scientific Corp.**, Inglewood, Calif., to provide computer programming and scientific analysis services for another year.

$365,316—**Canoga Electronics**, Canoga Park, Calif., for teltrac system for Project *Gemini*.

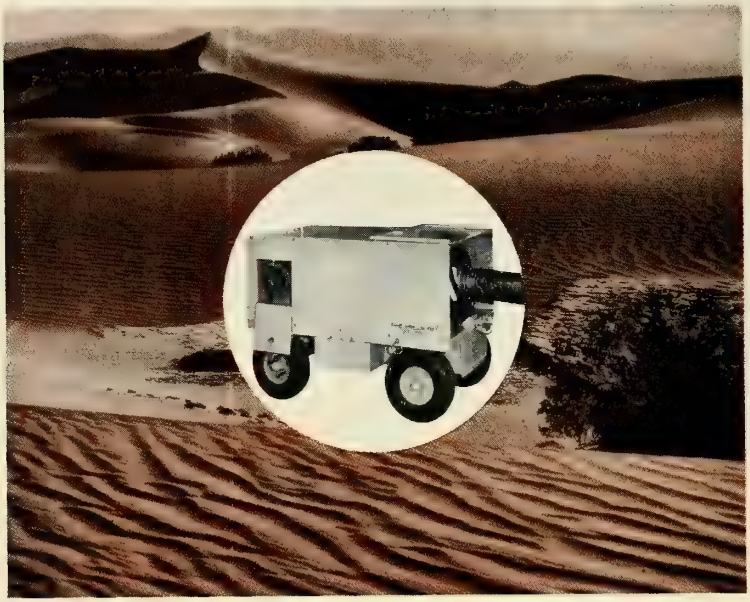
$339,620—**Pearce, DeMoss & King, Inc.**, Decatur, Ala., for construction of addition to central communication facility, Marshall Space Flight Center.

INDUSTRY

$6,111,000—**Northrop Corp.**, Nortronics Div., Beverly Hills, Calif., from **North American Aviation, Inc.**, Autonetics Div., Anaheim, Calif., for production of auxiliary gyroscopes used in the *Minuteman II* inertial guidance system.

$1,000,000—**International Telephone and Telegraph Corp.**, San Fernando, Calif., from **Martin Co.**, Orlando, Fla., Div., for exploding bridgewire firing devices for the *Pershing*.

$300,000—**Adage, Inc.**, Boston, from **General Electric Co.**, Military Communications Div., Oklahoma City, Okla., for special high-speed analog-to-digital converters.



No job is too dusty for AAF ENVIRONICS*

The F-10 Explosion-Proof Air Filtering Unit shown above, for example, was developed by AAF to provide a source of clean, oil-free air for military ground support applications. It is typical of the units designed and built by AAF for environmental control at defense installations on every part of the globe. Characterized by its special grounding provisions and spark-proof construction, the F-10 filters out 95% of all particles one micron or larger, as well as 95% of all absorbable vapors. It is rated at 1150 cfm with full air flow.

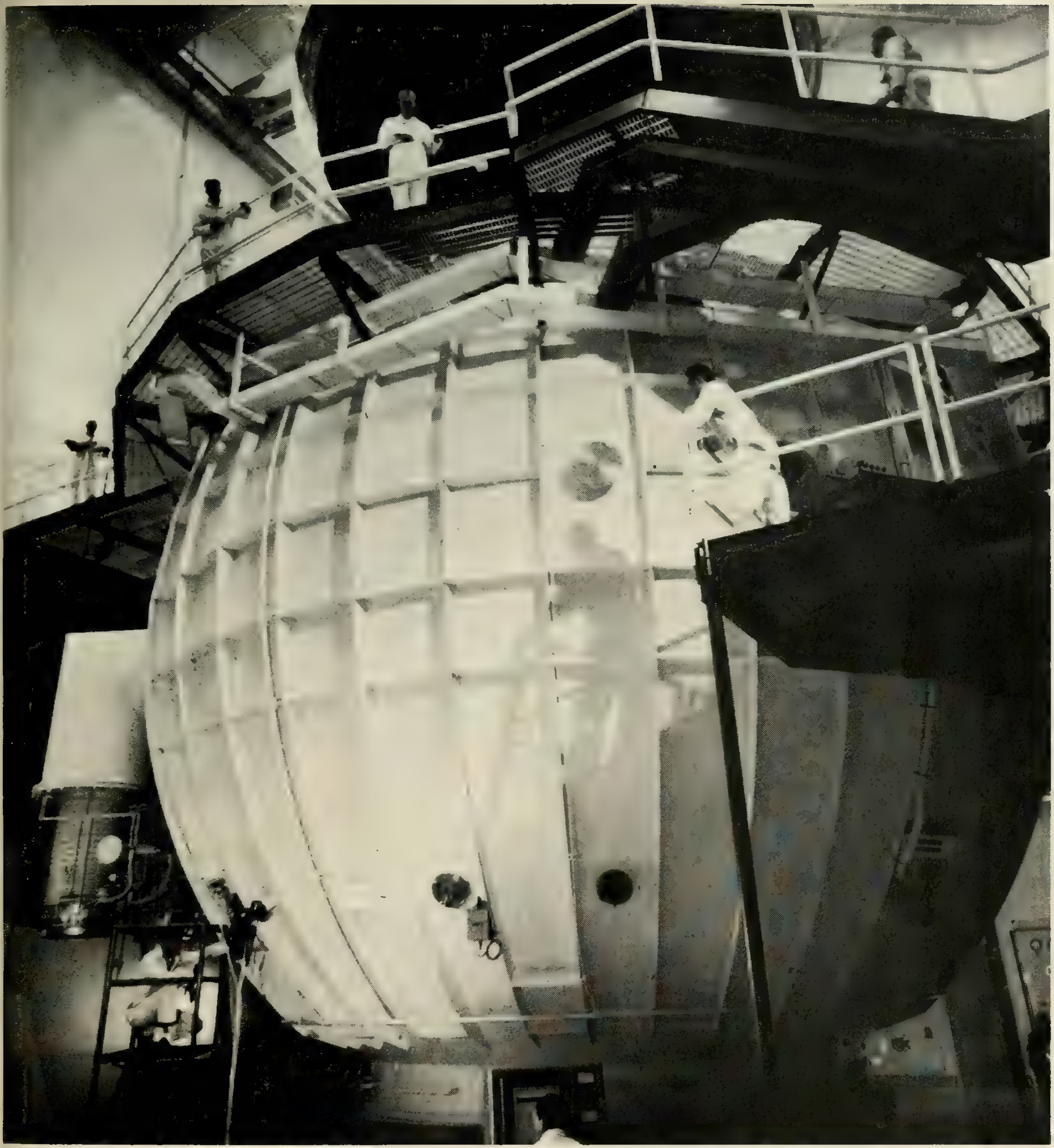
Can we help you with environmental control problems? Phone or write Defense Products Group, American Air Filter Co., Inc., 1270 N. Price Rd., St. Louis, Mo. 63132. Ask for Bulletin D-240.

American Air Filter

* *Our total system approach to R&D, production and engineering management of package environments involving heating, ventilating, air filtering, refrigeration, humidity control and purification.*

AAF

Circle No. 14 on Subscriber Service Card



inside: 400° below, 500 miles up

When the lid closes on this huge steel ball, it goes to work on simulating the deep cold and airlessness of outer space. We use it to test space systems in an environment similar to those on missions.

Our space-ball can handle units 30 feet long, simulate altitudes up to 500 miles... bring temperatures down to close to 400 degrees below zero. And an air-lock chamber is in the works to man-rate it. It is a big step forward in solving the space environment problems of the aerospace industry.

There's lots of other space simulation equipment in this building, too. And it is only one of eleven modern units in our new Space Systems Center. They comprise the finest privately-owned space complex in the world.

DOUGLAS
MISSILE & SPACE SYSTEMS GROUP

MISSILES AND ROCKET

[illegible]

HIRD ANNUAL DOD ISSUE, March 29, 1965

advanced technology and the DOD

Advanced Technology is the key to growth n the future. The March 29 issue of MISSILES AND ROCKETS will concentrate on the applications of advanced technology to actical warfare. It will encompass all phases of advanced technology for which the Defense and Space Industries have a unique capability and for which the DOD has unique requirements.

This issue will cover:

Advanced Technology: materials, electronics, power sources and basic research

Systems: combat support, air defense, command and control, mobility, and counter-insurgency

Plus these valuable guides:

Complete organization charts, procurement contacts and all defense level organizations involved in tactical warfare including DDR&E and ARPA.

Your advertising will have greater impact, greater importance and greater readership among the men making the important buying decisions in the military and industry.

PLAN NOW TO CAPITALIZE ON THIS UNIQUE EDITORIAL ATMOSPHERE.

M/R

Advertising Closes: March 15, 1965

Issue Date: March 29, 1965

New Product of the Week: Rocket Photometer

A modular photometer system for a variety of sounding rocket experimental applications has been announced by Spectrolab Div. of Textron Electronics, Inc.

The RD-100 system detects light energy with a photomultiplier tube, amplifies it and converts it to an electrical output signal for direct read-out or transmission by telemetry. A variety of ultraviolet, visible and near infrared detection systems can be assembled for special experiments using standard modules.

The unit has a threshold sensitivity of 10^{-13} watts/cm.^{2} and output to telemetry of 0 to 5v dc. Power requirement is 56v dc, approximately four watts per channel. Typical environmental specifications include vibrations of 20 g's up to 3,000 cps; shock of 20 g's, 11-ms duration and temperatures ranging from −10° to 50°C.

Available accessories include multilayer interference filters in a wavelength range of 3,000 to 18,000 Angstroms and a filter wheel holding 5 filters.

Circle No. 151 on Subscriber Service Card

Inspection Stand

A free-floating inspection stand that permits optimum accuracies to be obtained from checking instruments has been developed by Herman Stone Co.

The stand removes vibration from ground level to workpiece and inspection devices. It provides isolation efficiencies ranging from 60% against a background disturbing frequency of 5 cps and up to 99% efficiency against 30 cps.

Isolation from vibration is achieved by a four-cylinder floating system upon which the 30 x 42-in. inspection table is mounted. Within each cylinder is a 12-in.-thick isolation pad of glass fiber insulation. The table can support loads up to 800 lbs. and features safety pads in case of overload.

Circle No. 152 on Subscriber Service Card

Pressure Transducer

Consolidated Controls Corp. has introduced a pressure transducer, designed for minimum power consumption and said to be particularly desirable in space applications.

The 41PD5 Ultradyne unit has an input requirement of 15 milliamps of unregulated 28v dc. Models with lower power consumption are available on order.

Output varies from 0 to 5c dc or ±2.5v over the pressure range of a particular unit. Available pressure ranges are from 0 to 0.1 psi to 0 to 5,000 psi, gauge, differential or absolute.

Circle No. 153 on Subscriber Service Card

Antenna Positioners

Andrew Corp. is marketing a line of single and dual-axis antenna positioners for parabolas up to 30-ft. diameter. Thirty-six designs and three shell sizes offer a selection of standard torque outputs, speeds and antenna capacities.

Standard positioners are designed for operation in 40-mph winds with 0.1-degree accuracy and survival at 125

This Apco Series Parallel Check Valve provides a one way street for helium in a fuel pressurization system for the North American Aviation's Apollo Lunar program, under direction of the NASA Manned Spacecraft Center, Houston. A single helium source pressurizes the fuel (UDMH or MMH) and oxidizer (N_2O_4) tanks through these valves. Thus, fuel and/or oxidizer cannot leak back through the lines and meet, causing hypergolic combustion. The series parallel valve not only keeps pressure traveling in one direction, but failure of any of the 4 poppets in either the open or closed position does not adversely effect the valve's performance. There is nothing to match this Apco Valve for safety and ultra-high reliability. It is an absolute zero leakage (2.5×10^{-6} cc/sec) valve both internally and externally . . . offers minimum line loss or restriction regardless of flow path . . . and is completely qualified and environmental-tested. The Valve is brazed in place—there are no bolts or fittings. "Traffic control" for helium is just one more example of how Apco, with full design, development, testing and manufacturing, works in the environment of the Space Age. If you have a critical problem involving similar sophisticated systems or components, Apco engineers are ready to make recommendations. ***Write, outlining your requirements.***

APCO **ACCESSORY PRODUCTS CO.**
FLUID CONTROL • SYSTEMS • COMPONENTS
A textron CO.
616 West Whittier Boulevard • Whittier, California

Circle No. 16 on Subscriber Service Card

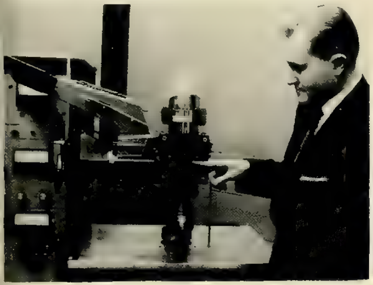
mph under rated loads. Standard electro-manual controls and solid-state power supplies are provided with each unit. Solid-state servo controls and higher pointing accuracies are offered for positioners with load capacities between 2,500 and 10,000 lbs.

Circle No. 154 on Subscriber Service Card

Field Ion Microscope

Materials Research Corp. has developed a field ion microscope composed of four subsystems: electrical, vacuum, cryogenic and optical.

The head of the unit is essentially a liquid hydrogen dewar with a vacuum chamber mounted on the bottom. This vacuum chamber has six service ports—three for the vacuum system; one connected to the phosphor screen and fibre optic window, one for the electrical feed-through and one left blank for feed-throughs for auxiliary apparatus.



The stainless steel head is bakeable to 400°C. The optical system has a 2-in.-dia. fiber optic window and the electrical system has a voltage supply of 0 to 25 kv, 0 to 1 ma. It features regulation for 20% line change, 0.01% ripple and 0.01% RMS.

Circle No. 155 on Subscriber Service Card

Crystal Oscillator

Monitor Products Co., Inc., is marketing a crystal controlled oscillator, coupled with an adjustable countdown chain which provides dual outputs in the 25-cps to 300-kc frequency range.

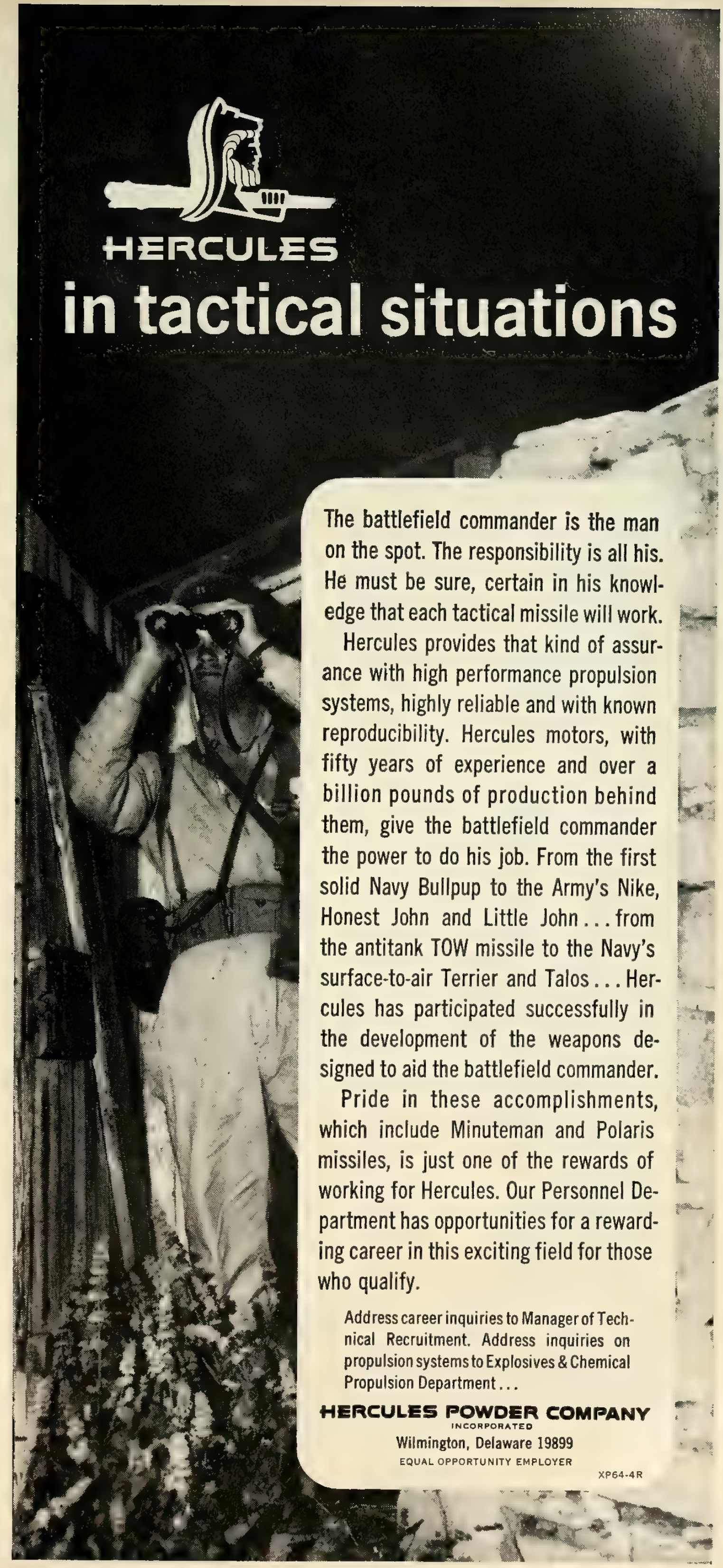
With the Type SO3111, frequency relationship between the two outputs can be any integer divisible by 2 through 10. Output is square wave, 4v peak to peak into a 2.2-k load. Stability is ±0.3 ppm. Input is 0.5 amps maximum at 28v dc to the oven and 32 ma to 28v dc to the oscillator. Operating ambient temperature range is —55° to 71°C.

Circle No. 156 on Subscriber Service Card

A-C Power System

International Electronic Research Corp. is marketing an elin precision ac power system, featuring advanced capabilities for running precision gyros.

The solid-state system provides a 5-kc



HERCULES

in tactical situations

The battlefield commander is the man on the spot. The responsibility is all his. He must be sure, certain in his knowledge that each tactical missile will work.

Hercules provides that kind of assurance with high performance propulsion systems, highly reliable and with known reproducibility. Hercules motors, with fifty years of experience and over a billion pounds of production behind them, give the battlefield commander the power to do his job. From the first solid Navy Bullpup to the Army's Nike, Honest John and Little John . . . from the antitank TOW missile to the Navy's surface-to-air Terrier and Talos . . . Hercules has participated successfully in the development of the weapons designed to aid the battlefield commander.

Pride in these accomplishments, which include Minuteman and Polaris missiles, is just one of the rewards of working for Hercules. Our Personnel Department has opportunities for a rewarding career in this exciting field for those who qualify.

Address career inquiries to Manager of Technical Recruitment. Address inquiries on propulsion systems to Explosives & Chemical Propulsion Department . . .

HERCULES POWDER COMPANY
INCORPORATED
Wilmington, Delaware 19899
EQUAL OPPORTUNITY EMPLOYER

XP64-4R

Circle No. 12 on Subscriber Service Card

MITRE NEEDS SYSTEMS MEN

MITRE works on the basic design and general system engineering of complex information, control, sensor, and communication systems for the United States Government. An important part of its mission is the development of new techniques in these areas and advancement of the general technology.

Immediate openings are available in:

COMMUNICATIONS — men with experience in communications systems for work on the engineering of communication networks, range instrumentation, tactical air control, and survivable communications.

SENSOR SYSTEMS AND TECHNIQUES — men needed to support theoretical and experimental programs on advanced radar and optical detection and tracking systems. Work includes feasibility and techniques analysis, systems synthesis and performance evaluation.

NATIONAL MILITARY COMMAND SYSTEM — men for systems analysis and feasibility studies, communications systems analysis, systems design, integration, and design verification.

COMPUTER PROGRAMMING TECHNIQUES — men with experience in the development and support of monitors, compilers, real time simulations, time sharing systems, etc.

TACTICAL SYSTEMS — men with experience in tactical, light-weight equipments for surveillance, communications, data processing and display . . . system test planning and evaluation and operations analysis.

SYSTEMS ANALYSIS — men with experience in military systems or operations analysis with a background in physics, mathematics, operations research, or industrial management.

If you have three or more years' experience and a degree in electronics, mathematics or physics, contact MITRE. Write in confidence to Vice President — Technical Operations, The MITRE Corp., Box 208G, Bedford, Mass. MITRE also has openings in Washington, D.C.

THE MITRE CORPORATION

An Equal Opportunity Employer

Pioneer in the design and development of command and control systems, MITRE was chartered in 1958 to serve only the United States Government. An independent nonprofit corporation, MITRE is technical advisor and systems engineer for the Electronic Systems Division of the Air Force Systems Command, and also serves the Department of Defense, and the Federal Aviation Agency.

Circle No. 17 on Subscriber Service Card

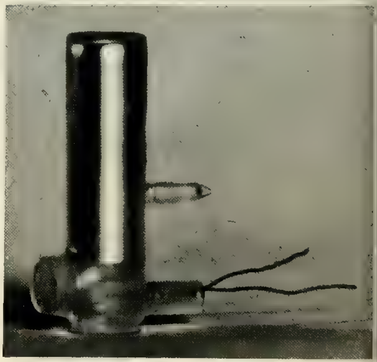
sine wave, 2-va microsyn supply and a 400-cps, 50-va, 3-phase wheel supply. Both supplies have ±0.005% load regulation and amplitude stability of ±0.01% per week.

Both supplies have a voltage stabilizing electronic servo in which the output voltage of the supply is average sensed, compared to an unsaturated standard cell for reference, and the differential is used to correct the output voltage.

Circle No. 157 on Subscriber Service Card

Diode Laser

Seed Electronics Corp. is marketing a gallium arsenide diode laser that converts a pulsed dc electrical input directly into a narrow band coherent infrared output at approximately 8,400 Å.



The Type S-5 operates at liquid nitrogen temperatures of 77°K. The laser is mounted on a gold-plated molybdenum tab to match the thermal expansion coefficient of the gallium arsenide and provide a heat sink. The unit is aligned to emit horizontally out a polished vertical observation window of 0.75-in. diameter.

Circle No. 158 on Subscriber Service Card

Voltage-Tunable Magnetron

Bomac Div. of Varian Associates is marketing the BTO-20 voltage-tunable magnetron. The magnetically shielded tube delivers at least 10 watts over any 600-mc. range specified between 2.6 and 3.7 gc.

The magnetic circuit configuration results in a negligible external magnetic field, permitting the tube to contact other ferromagnetic materials without degrading performance. The integral heat sink allows the device to operate within specifications for over two minutes without auxiliary cooling, starting from an ambient temperature as high as 160°F.

General characteristics include a minimum CW power output of 10w; power flatness of ±1 db; modulation sensitivity of 1.8 ±0.1 mc/v; maximum anode voltage of 2,300v dc; and injection electrode voltage of 525 ±50v dc.

Circle No. 159 on Subscriber Service Card

Calibration System

A combined vibration-temperature calibration system, the System 300T, is available from Unholtz-Dickie Corp. The unit is said to offer high g levels and high frequencies for the first time in combination with temperature calibrations of piezoelectric accelerometers.

Temperatures can be controlled from −100° to 300°F in one model. Other ranges are available. Calibrations to 100-g acceleration up to 10,000 cps can be run on test accelerometers at the controlled temperature. Calibrations use the comparison method with back-to-back mounting of test and reference accelerometer.

Circle No. 160 on Subscriber Service Card

Seismic Recording System

The 600 Series seismic recording system, which will accept 24 channels of seismic input information and two channels of timing information, is being marketed by Redcor Corp.

The system will multiplex data together, digitize the data at rates up to 1,000 samples/second/channel and record digitized data on magnetic tape for computer use. The tape can then be played back through the system and reassembled into analog form. The solid-state unit can operate from standard commercial power or may be converted to operate from a battery supply capable of generating up to 2 kva ac.

Circle No. 161 on Subscriber Service Card

Leak Detector

A mass-spectrometer leak detector, designed for a broad range of vacuum and gas leak detections including space simulation, has been developed by General Electric Co.'s vacuum products operation.

The device is able to detect leaks as small as 2 x 10^{-11} cubic centimeters per second. Maximum operating pressure is rated at 0.2 micron at the analyzing tube and amplifier drift does not exceed 2% of full scale per hour.

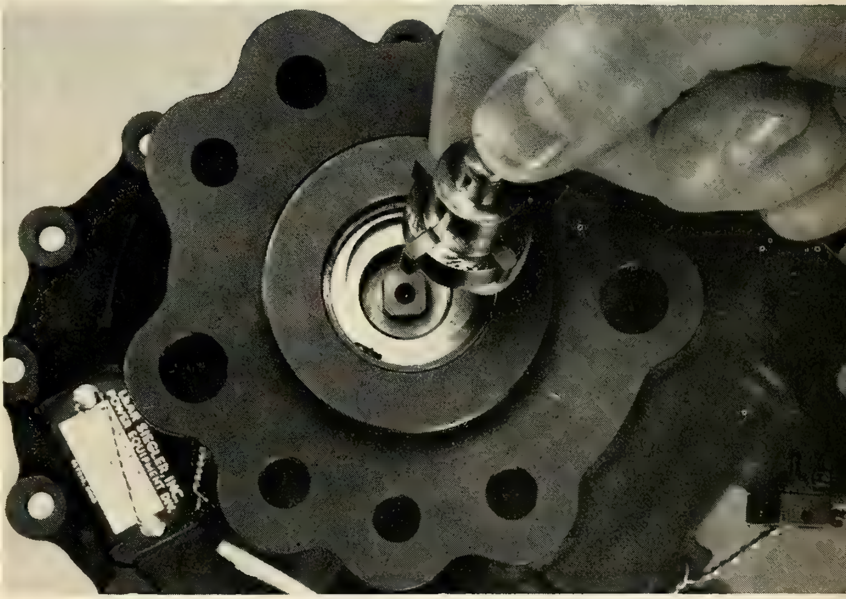
It is available in two models, LC-20 and LC-10, with or without the automatic test station. The detector features triple protection for the tube filament to eliminate burn-out of the mass spectrometer tube. Input is 120v, 60 cps.

According to GE, the system combines ultrastable solid-state electronics with high-detection sensitivity.

Circle No. 162 on Subscriber Service Card

25
10
5
DEF
3
ABC
2
GHI
4
1
COIN RELEASE
PUSH

You make the call...



B-2346-LS-R

We make the pump!

We'll find an ingenious solution to your most difficult liquid and gas handling headaches . . . just as we have been doing for 40 years for all major defense contractors and government agencies. Special pump configurations, pumping packages and integrated hydraulic, cooling and pressurization systems are our business. As the only major pump manufacturer in continuous production of all four basic pump structures . . . gear, vane, centrifugal and piston . . . as well as couplings and valves, we can make that phone call pay off. Brief us and we'll do the rest . . . economically and in record time.

LEAR SIEGLER, INC.
LSI ®
POWER EQUIPMENT DIVISION
ROMEC FACILITY
241 South Abbe Road, Elyria, Ohio 44038
Phone 216-323-3211

Electro-mechanical systems are designed by our Aerospace Facility in Cleveland.

Circle No. 18 on Subscriber Service Card

names in the news

DIERKS

DORRENBACHER

LINTNER

STANTON

Gordon F. Dierks: Joined Rocket Research Corporation as a propellant chemist. A specialist in high-energy rocket propellants, he was formerly with Aerojet-General where he worked on *Polaris* research and development.

C. J. Dorrenbacher: Appointed vice president-advance systems and technology of the Douglas Aircraft Company's Missile & Space Systems Division. **C. S. Perry** was also appointed vice president-development engineering.

Richard M. Lintner: Elected vice president of System Development Corporation, along with **Dr. Thomas C. Rowan.** Lintner is also manager of the Defense Systems Division and Rowan is manager of the Advanced Systems Division. Both men will continue to serve in these capacities.

Peter H. Stanton: Acquired Aerospace Components Corporation from G. H. Tennant Company of Minneapolis. He will manage the company as its president. The company manufactures high-precision fluid filters, valves and metallic seals for aerospace and industrial applications.

Enrico Medi: Resigned from his posts as vice president and member of the Commission of the European Atomic Energy Community. His resignation will take effect on March 1, 1965. The member states of the Community will designate a successor for the position.

Dr. George M. Knauf: Will join the Boeing Company Jan. 1 as chief of bioastronautics. He has been deputy director of space medicine in the Office of Manned Space Flight for NASA for the past three years. He will continue his association with NASA as a consultant to the director of space medicine on administrative and operational problems.

Theodore P. Wright: Elected president of Associated Universities, Inc., (AUI), the organization which administers Brookhaven National Laboratory and the National Radio Astronomy Observatory. He was formerly vice president for research at Cornell University.

Professors William F. Neuman and Aser Rothstein: To become co-chairmen of the University of Rochester Department of Radiation Biology and co-directors of the Atomic Energy Project on July 1, 1965. They will alternate administrative responsibilities every two years, with Neuman serving first in that capacity from 1965 to 1967.

Edward G. Cook: Elected president of the Ultrasonic Manufacturers' Association. He is president of Crest Ultrasonics Corp.

Fred L. Brengl: Elected executive vice president of Johnson Service Co., Milwaukee. **William L. Rootham** has been elected vice president and general sales manager to succeed Brengl. He was formerly with Johnson Controls Ltd., Toronto.

Charles Fiedelman: Elected president of Cooke Engineering Co. He was formerly with the Navy's Bureau of Ships as civilian head of the electronics logistics division.

James T. Courtney: Elected treasurer of Ion Physics Corp., the aerospace research and development subsidiary of High Voltage Engineering Corp. He has been manager of accounting of IPC since 1962.

Dr. Lawrence M. Liggett: Appointed vice president of research and development at Speer Carbon Co., a division of Air Reduction Co., Inc. He succeeds **Dr. Robert L. Womer,** who has resigned as vice president-technical director.

Emile J. E. Van Dyck: Appointed director of the Strategic Industries Assn. He is also a senior vice president of U.S. Polymeric Chemicals, Inc.

Sheldon A. Davis: Named director of industrial relations for Thompson Ramo Wooldridge Space Technology Laboratories, succeeding **James E. Dunlap,** newly appointed TRW vice president-human relations. He was formerly associate director for industrial relations.

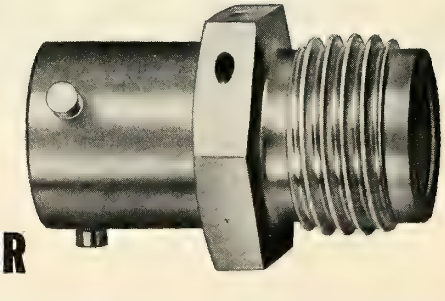
Donald G. Dockum: Joined General Dynamics/Electronics as programs manager for anti-submarine warfare. He will administer plans, task teams, schedules, budgets and controls for development of ASW products.

Mark Kato: Appointed director of quality, reliability and assurance at Telemetrics, Inc., a subsidiary of Technical Measurement Corp.

Kermit R. Dyke: Named director of North American Aviation's Washington Office. He was formerly senior representative and coordinator of requirements information in the Washington office.

Charles Yaker: Appointed executive vice president of Misco Precision Casting Co., a division of Howe Sound Co.

Dr. Frank E. Myers: Named editor of the "Journal of Applied Physics" and "Applied Physics Letters." He is associate laboratory director for education of Argonne National Laboratory. Named as associate editors of the two journals are **Dr. Lester Guttman,** senior chemist, solid state science division, and **Dr. Foster F. Rieke,** senior physicist, radiological physics division, Argonne National Laboratory.



1 AMP
1 WATT
INITIATOR

Developed and tested to meet the most severe aerospace applications. S01 Series Standard Pressure Cartridge exceeds AFMTCP 80-2 1 amp/1 watt 5 minute "No Fire" RF requirements. Now in production—available for the operation of many types of ordnance-energized systems.

Get Complete Information on This And Other Ordnance Products From

SOS **SPACE ORDNANCE SYSTEMS, INC.**

RESEARCH
DESIGN
DEVELOPMENT
MANUFACTURING

133 PENN STREET, EL SEGUNDO, CALIFORNIA 90246/213-772-5461
Send for General Catalog and Capabilities Brochure

Circle No. 15 on Subscriber Service Card

Advertiser's Index

ADVANCED SCIENTIFIC INSTRUMENTS 2
Agency—Thompson Grande Adv.

AMERICAN AIR FILTER CO. 44
Agency—Zimmer, McClaskey, Lewis, Inc.

APCO DIV. OF TEXTRON, INC. 48
Agency—Swain/Mealer, Inc.

ARINC RESEARCH CORP., SUB. OF AERONAUTICAL RADIO, INC. 53
Agency—Diener & Dorskind, Inc.

ATLAS CHEMICAL INDUSTRIES, INC., AEROSPACE COMPONENTS DIV. 10
Agency—Harris D. McKinney, Inc.

BENSON-LEHNER CO., THE 32
Agency—Leonard Daniels Adv.

BOEING AIRPLANE DIV. 33
Agency—Forbes, Inc.

CERAMICS INTERNATIONAL 7
Agency—Conti Adv. Agency, Inc.

CHANDLER EVANS CONTROL SYSTEMS DIV., COLT INDUSTRIES 56
Agency—G. F. Sweet & Co., Inc.

COMPUTING DEVICES OF CANADA LTD. 13
Agency—Ardiel Adv. Agency Ltd.

CUBIC CORP. 31
Agency—Phillips-Ramsey, Inc.

DEFENSE ELECTRONICS, INC. 8
Agency—GLM Associates, Inc.

DOUGLAS AIRCRAFT CO., INC.
AIRCRAFT GROUP 4
MISSILE & SPACE SYSTEMS GROUP .. 45
Agency—J. Walter Thompson Co.

GENERAL ELECTRIC CO., MISSISSIPPI TEST SUPPORT OPERATION 3
Agency—Deutsch & Shea, Inc.

GENERAL ELECTRODYNAMICS CORP. .. 22
Agency—Glenn Adv., Inc.

GRUMMAN AIRCRAFT ENGINEERING CORP. 26
Agency—Newmark, Posner & Mitchell, Inc.

HERCULES POWDER CO. 49
Agency—Fuller & Smith & Ross, Inc.

HONEYWELL, DENVER DIV. 40
Agency—Campbell-Mithun, Inc.

HUGHES AIRCRAFT CO. 30
Agency—Foote, Cone & Belding

HYDRO-AIRE, DIV. OF CRANE CO. 11
Agency—Scott, Rifkin & Wilson, Inc.

LEAR SIEGLER, INC., POWER EQUIPMENT DIV. 51
Agency—Penn & Hamaker, Inc.

LOCKHEED AIRCRAFT CORP. 28, 29
Agency—Foote, Cone & Belding

McDONNELL AIRCRAFT CORP. 55
Agency—John Patrick Starrs, Inc.

MARTIN CO. 35
Agency—Ketchum, MacLeod & Grove, Inc.

MITRE CORP., THE 50
Agency—The Bresnick Co., Inc.

NORTH AMERICAN AVIATION, INC. .. 42
Agency—Batten, Barton, Durstine & Osborn, Inc.

RAYMOND ENGINEERING LABORATORY INC. 12
Agency—The F. W. Prelle Co

REEVES SOUNDCRAFT CORP. 11
Agency—The Wexton Co., Inc.

SPACE ORDNANCE SYSTEMS, INC...... 52
Agency—Lynn-Western, Inc

—when and where—

FEBRUARY

1965 Western Metal and Tool Exposition and Conference, sponsored by the American Society for Metals and the American Society of Tool and Manufacturing Engineers, Great Western Exhibit Center and Biltmore Hotel, Los Angeles, Feb. 24-26.

Annual Meeting of the Aerospace Systems Safety Society, International Hotel, Los Angeles, Feb. 24-26.

Fifth National Symposium of the Society for Information Display, Miramar Hotel, Santa Monica, Calif., Feb. 25-26.

MARCH

Unmanned Spacecraft Meeting, sponsored by the AIAA, International Hotel, Los Angeles, March 1-4.

Twenty-first Annual Technical Conference of the Society of Plastics Engineers, Statler-Hilton Hotel, Boston, March 1-5.

Design of Space Systems for Power and Temperature Control Course, University of California at Los Angeles, March 1-12.

Advanced Planning Briefings for Industry, sponsored by the Department of Defense and the National Security Industrial Assn., Ambassador Hotel, Los Angeles, March 3-4.

Fifth International Symposium on High Speed Testing, sponsored by Massachusetts Institute of Technology and Brooklyn Polytechnic Institute, Sheraton Plaza Hotel, Boston, March 8-9.

Marine Systems and ASW Conference, sponsored by the AIAA and the Navy, San Diego, March 8-10.

West Coast Symposium on Arms Control, sponsored by the American Ordnance Assn. and TRW Space Technology Laboratories, Los Angeles, March 8-10.

Integrated Circuit Engineering Management, Design and Applications Seminar, sponsored by the Integrated Circuit Engineering Corp., Phoenix, Ariz., March 8-12.

Workshop-Seminar: Analysis of Viscoelastic Materials for Engineering Applications and Product Design, sponsored by the Plas-Tech Equipment Corp., Boston, March 10-12.

Particle Accelerator Conference, sponsored by the IEEE, Shoreham Hotel, Washington, D.C., March 10-12.

Third Annual Conference on New Horizons on Quality and Reliability, sponsored by the IEEE, Harpua College, Binghamton, N.Y., March 13.

CLASSIFIED

FOR SALE OR LEASE
5000 GALLON—53# W. P. DEWAR SUITABLE FOR OXYGEN, NITROGEN, OR HYDROGEN. AVAILABLE IMMEDIATELY.
NATIONAL ANNEALING BOX COMPANY
Washington, Pennsylvania

ENGINEERS
SCIENTISTS

. . . for our expanding activities at our Huntsville, Ala. branch office, in the following areas:

- Reliability
- Propulsion
- Mechanical
- Information Retrieval
- Design
- Structures
- Data Systems
- Operations Research

Investigate these career opportunities. For interview, send resume in confidence to Mr. P. Sevec, Personnel Manager.

ARINC research corporation
A subsidiary of
AERONAUTICAL RADIO, INC.
1700 K St., NW
Washington, D.C. 20006
An equal opportunity employer

Circle No. 23 on Subscriber Service Card

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Geneva, Switzerland—10 Rue Grenus; Geneva 321044

Paris, France—11 Rue Condorcet; TRU 15-39

Problems for the Hill

CONGRESS NOW IS TAKING UP the arduous task of evaluating the defense and space budgets which the Administration has sent to the Hill. As we said when the budgets were released, we feel that the $24 billion available to the industry in the Fiscal 1966 budgets has, in general, been wisely apportioned.

The committees of Congress, however, must concern themselves in detail with the decisions made. In particular, they will be taking a close look at the cutbacks of the big solid booster program, the M-1 engine and the SNAP 8.

NASA Administrator James E. Webb has made it clear that he would like to see funds restored for the three crippled programs. A sampling of Hill opinion indicates there is considerable sentiment to back him up. Best bet at this point is that money will be made available for continued work in the three areas, either directly or through re-programming and stretch-out.

We hope the committees take a close and searching look at the needs in these areas, for this is indeed the time to raise questions about them. If the answers are in the affirmative, it should be a strong affirmative—so that the exercise will not have to be repeated next year. If the answers are in the negative, the reasons why should be quite clear—so that the industry can devote its attention to more productive areas.

Behind the cutbacks are some hard-to-swallow facts of life as well as some unanswered questions to which the committees should seek answers.

On the basis of Administration decisions, there appears to be little requirement for the big solids for many, many years—if ever. The Air Force sees its *Titan III-C* family of boosters fulfilling all its foreseeable needs for launch vehicles of this type. For payloads beyond this capability, assembly in orbit is seen as a better answer than larger and more cumbersome boosters.

NASA has been told to lower its sights somewhat for advanced missions, concentrating attention on missions that can be carried out by hardware already in development. The Administration is saying, in effect, that the taxpayer has put up considerable sums of money to buy *Saturn* and *Apollo* systems and that the fullest use should be made of these before there is any further large-scale undertaking requiring new hardware.

Just what would be done with a motor of 260-in. size therefore is open to question. Engines, however, have been a pacing item for the industry ever since Orville and Wilbur flew the first airplane. There seldom has been an aircraft or space program which could not have made good use of more power. It may be sound, therefore, to have such options as a 260-in. motor would make available.

Carrying the 260-in. program through firing of full-scale motors could be justified on grounds that we should have this off-the-shelf "building block" technology ready if needed. No one is far-sighted enough at this point in time to say authoritatively that we will never need a motor of this size. There are still too many unknowns in space for such assurance.

Yet the committees should examine in depth the state of the art in big solids. Great strides have been made in the past two years in taking this technology firmly in hand.

Problems of segmentation, insulation, motor-case fabrication, materials, nozzles and vector control have been met and overcome with astonishing success. As an example, liquid injection, jet tabs and movable nozzles all have been developed and demonstrated as acceptable for vector control of big solids.

The very success of the big solids manufacturers may be the weakest link in their argument for continuation of the program. Their past claims that solid motors can easily be scaled upward have been backed up by the feasibility programs.

PAINFUL THOUGH IT MAY BE, it thus becomes necessary to ask just what further work on the 260-in. motor is worth. Is it already well within the state of the art? If so, further development would contribute nothing to the advancement of technology and the 260-in. option already exists in fact. Such a condition should preclude further expenditure. We are not saying this is fact. But the question is one to which Congress should obtain a factual answer.

Frankly, we believe the small additional amount of money now required to carry the scheduled 260-in. work through firing probably makes it worthwhile to do so regardless of the answer to the question. But Congress should have all the facts.

The same question should be asked in relation to the M-1 and SNAP 8 programs. When so many important areas are lacking funds, no money should be wasted. We strongly favor programs that advance technology—even where no requirement is in sight. But there is no sense whatever in spending money on projects which not only lack requirements but fail to advance technology.

The promising market area for big solids, including those up to 156-in. size, is in combination with present liquid boosters. United Technology Center's David Altman puts it this way in the current issue of *Astronautics and Aeronautics*:

"The obvious answer is to blend our capabilities in the liquid and solid fields. This road will allow us to use the existing technology to extend our goals by a factor of 2 and more, with relatively little development expense and in a relatively short development period. As an example, the strap-on system, which has already been developed in the *Titan III-C* to improve the performance of the liquid-core *Titan III-A*, can be applied equally well to larger liquid systems including the *Saturn* booster. Moreover, the use of a clustered-solid first stage with one of the present liquid boosters as the second stage represents a further means of providing large thrust capabilities with already developed units."

This approach also will enable the devotion of adequate time and money to propulsion concepts much more advanced than any now in existence.

William J. Coughlin

LET'S SWAP RESUMES

The McDonnell Electronic Equipment Division is currently engaged in more than 200 projects and programs. Its advanced developments span the sciences from thin-film circuitry through complete systems; temperature problems range from cryogenics through extremes of reentry heating.

Present and planned programs have created these career opportunities at the Managerial level:

Responsible for concept, design, analysis and development of electronic equipment in areas of:

• MICROELECTRONICS • COMPUTERS & AUTOMATION • SPACE INFORMATION SYSTEMS • SURFACE COMMUNICATIONS • TRAINERS & SIMULATORS • PROCESS CONTROLS • AUTOMATED CHECKOUT • BIOMEDICAL SYSTEMS • ASW • NUCLEAR STUDIES • ECM & ECCM.

McDonnell's educational assistance program plus the convenience of nearby St. Louis and Washington Universities are additional incentives to select the **Electronic Equipment Division** for your career.

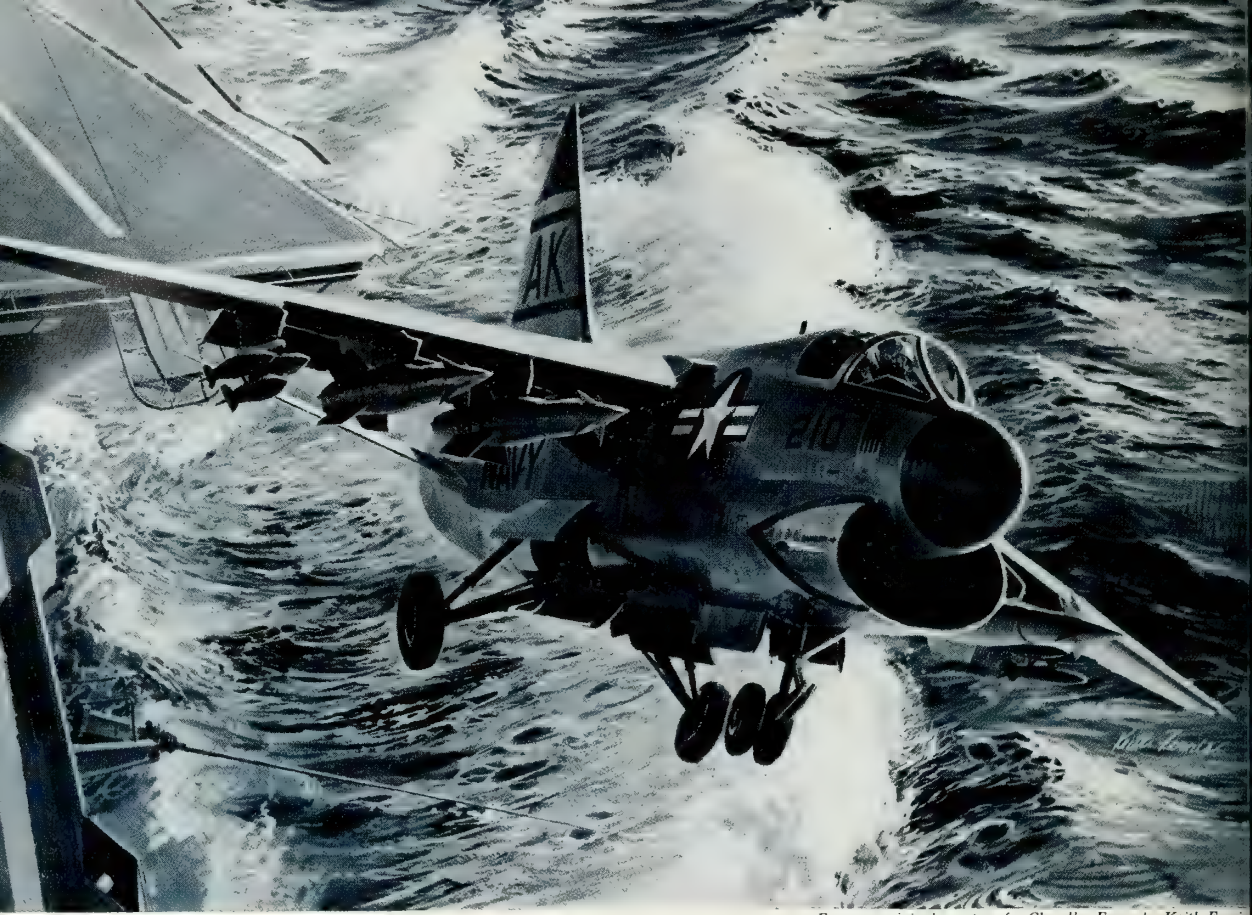
To arrange for convenient interview, please complete the attached coupon. All information will be confidential.

MCDONNELL, P.O. Box 516, St. Louis, Missouri 63166
Att: W. R. WARDLE, Engineering Employment Office, Dept. PP-222

Name________ Home Address________
City & State________ Phone________
Present Position________
Primary Experience Area________ No. of years________
Education: AE____ ME____ Math____ Physics____ Chemistry____
EE____ Bus. Adm.____ Other________
Degree: BS____ date MS____ date PhD____ date

MCDONNELL
ELECTRONIC EQUIPMENT DIVISION
An equal opportunity employer

Circle No. 19 on Subscriber Service Card



From an original painting for Chandler Evans by Keith Ferris

CECO Main Fuel Pump selected for LTV A-7A

The A-7A, a light attack aircraft being developed for the Navy by Ling-Temco-Vought, is powered by a Pratt & Whitney Aircraft TF-30 jet engine—equipped with a main fuel pump engineered and precision-produced by Chandler Evans.

This CECO product on the A-7A joins a distinguished line of pumps, main fuel controls, afterburner controls and other aerospace components in an array of important military aircraft as well as many of the latest and finest missiles and commercial aircraft.

Chandler Evans is pleased to be "known by the company its products keep" and by the records those products establish.

Colt Industries **Chandler Evans Control Systems Division**

WEST HARTFORD, CONNECTICUT 06101

GAS TURBINE FUEL CONTROLS/PUMPS • MISSILE CONTROL SYSTEMS/SERVOS • AIRCRAFT/ENGINE ACCESSORIES

Circle No. 20 on Subscriber Service Card

MARCH 1, 1965

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

HOUSTON PUBLIC LIBRARY
Houston Texas

NOSE FAIRING
55-0513-8
AC-5

Ranger IX May Study Surveyor Landing Site

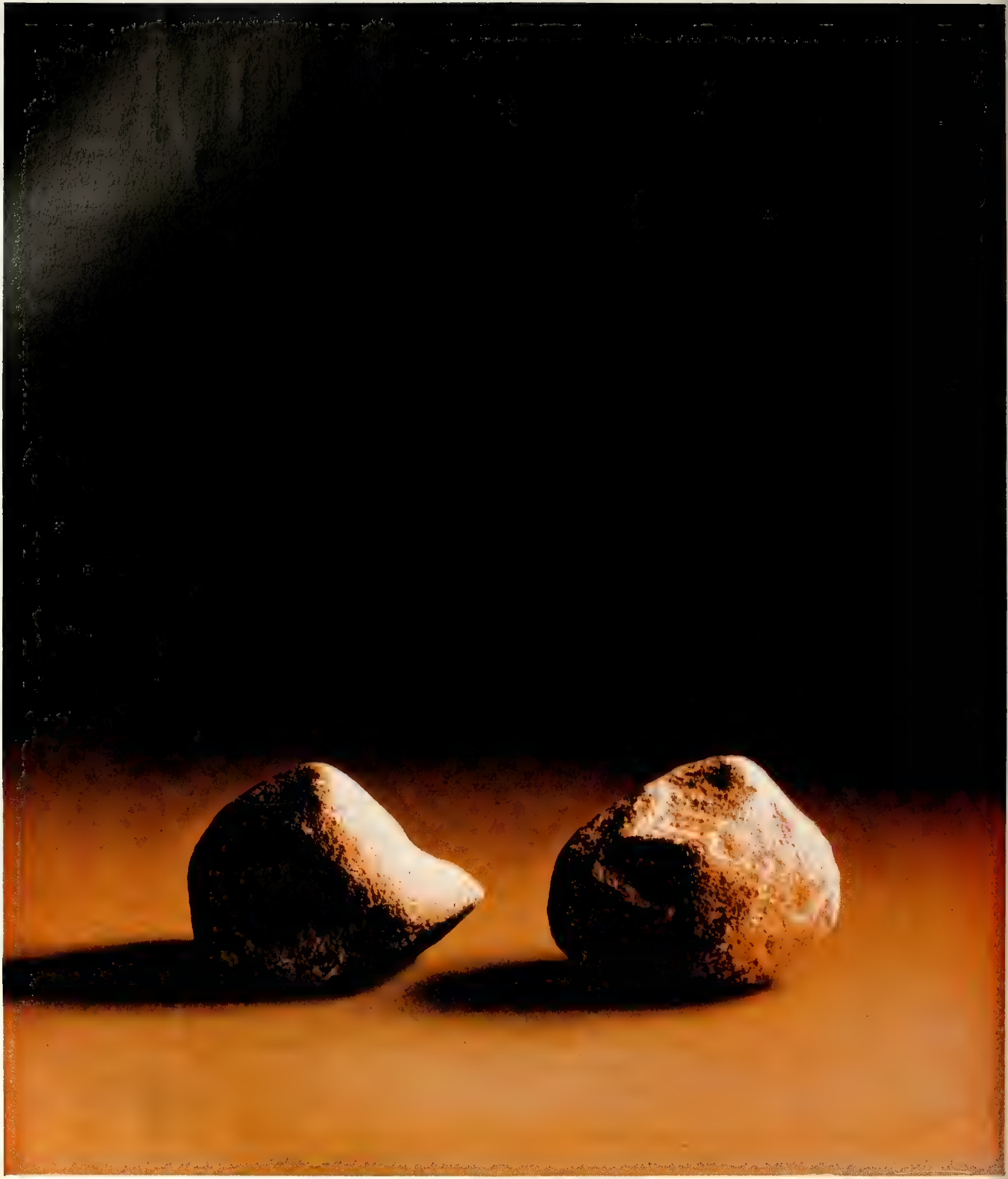
MOL Study Awards Due Soon

Versatility Key To Voyager Plans

LPC Eyes Small Motor Market

Surveyor Model Mated To Centaur Nose Fairing

AN AVIATION
N



The spark that ignited the solid state sciences was struck by primitive man. Today — reaching for the planets — man still draws strength from the earth. At Sperry Rand, research chemists and physicists are refining and reconstituting the very materials of man's environment, shaping them to his increasingly complex needs. Emphasis is on optics, magnetism, acoustics, semiconductors, microelectronics. From this research has come the first transfer of fluorescent energy between rare earth ions, to improve optical pumping efficiencies... the first semiconductor photoparametric diode, combining billionth-watt detection with low noise amplification... the first generation of second sound in a solid — presaging simpler radars, sonars and computers. Equally important discoveries lie ahead. **SPERRY RAND RESEARCH CENTER, Sudbury, Mass.**

SPERRY
DIVISION OF
SPERRY RAND
CORPORATION

Circle No. 1 on Subscriber Service Card

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY
Volume 16, Number 9
March 1, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors
Charles D. LaFond................Electronics
William S. Beller................Engineering

Associate Editors
Lawrence J. Curran......Assistant Managing Editor
Heather M. David..................Space Medicine
Michael Getler.......................Electronics
John F. Judge................Propulsion/Materials
Robert L. Parker......................Copy Editor
Rex Pay...............................Electronics
Hal Taylor...............................NASA
James Trainor..........................Military
Donald L. Zylstra......................Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach..................Art Director
Donald Strickland............Assistant Art Director
Suzanne Montgomery............Editorial Assistant
Sally Fosnight...................Editorial Assistant

BUREAUS
LOS ANGELES.....9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks..................Bureau Chief
NEW YORK..................20 East 46th Street
Michael Getler
CAPE KENNEDY ....507 Orange Ave.
Merritt Is., Fla.
MIDWEST ....423 N. Quentin
John L. Zimmerman ....Wichita, Kan.
PARIS...........................11 Rue Condorcet
Jean-Marie Riche

EDITORIAL ADVISORY BOARD
Dr. Peter Castruccio
Alexander Satin
Conrad H. Hoeppner
Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton............National Sales Manager
Paul B. Kinney........Eastern Advertising Manager
Edwin J. Denker, Jr.....Western Advertising Manager
Kenneth C. Blanchard.Marketing & Research Director
John N. Carlin..............Director of Circulation
Paddy Nelson................Circulation Promotion
R. Virgil Parker............Director of Production
Barbara Wiener........Advertising Services Manager

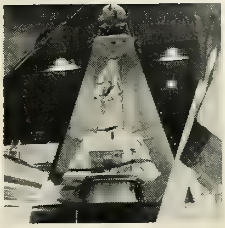
Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President.......................Wayne W. Parrish
Senior Vice President.............Louis C. James
Vice President......................Fred S. Hunter

THE COVER



Dynamic model of Surveyor spacecraft is fitted in Centaur nose fairing during "match mate" test at General Dynamics/Astronautics, San Diego. Fifth flight of Centaur, scheduled for March 2, will insert model on simulated lunar transfer trajectory. See story, p. 11.

MARCH 1 HEADLINES

Seven Firms Bidding on Preliminary Voyager Design .. 8
Air Force Considers Bigger ASSET Follow-on 8
NASA Promises Congress a Highly Versatile Voyager .. 10
Centaur Set for Debut as Payload-Orbiting Vehicle 11
Webb May Ask $10 Million for 260-in. Solid Work 11
Sixth ASSET Flight Successful But Vehicle Lost 12
McNamara Indicates MOL Study Awards Are Due Soon . 13

LUNAR EXPLORATION

Ranger IX May Photograph Surveyor Landing Area .. . 18

LUNAR STUDIES

Ames Research Enhancing Crater Extrapolation 23
Bendix Uses 'Moon Glow' to Aid in Mapping 25

PROPULSION ENGINEERING®

Goodyear Finishes Five-Ton Liner for 260-in. Nozzle ... 27
LPC Now Considering High-Production Smaller Motors . 28

SPACE ELECTRONICS

Symposium Foresees Vast Growth in On-Line Computing 32
RCA High-Speed Film Processor To Aid ASW Programs . 34

DEPARTMENTS

Letters 4
The Countdown 7
The Missile/Space Week® 8
Technical Countdown .. 17
Products & Processes .. 36
The Industry Week 39
Contracts/Procurements 40
Names in the News ... 42
When and Where 43
Editorial 46

47,850 copies this issue

Cheap at the Price

To the Editor:

Subject: *Et Tu, Brute*

How many luncheon or dinner checks do LBJ and McNamara pick up in the course of a busy week? Are the people invited to breakfast at the White House being bought—or informed?

The point is that there are not enough hours in a business day to get everything done. In a competitive selling situation, the use of any time with a buyer is worth a great deal to the seller.

The buyer gets his hour for lunch from his employer. If he is willing to work over his lunch hour, he makes more inroads on his workload than would otherwise be possible. His employer ought to be grateful—and the seller, too, to the point where he is more than happy to pay for the lunch in return for the buyer's ear for that period of time.

The Taxpayer pays for the expenses of both Johnson and McNamara. The Taxpayer does NOT pay for the seller's expenses—because his company's taxes, based on his successes or failures, take care of that item, not to mention the individual income taxes of the employees of the subject company—and its suppliers and subcontractors.

The Taxpayer pays for products and services—from industry's incredible electronic gear to Paternal Government's incredible clerical redundancy, from storage bills for mountains of food surpluses to dollars going to the rich in starvation-level countries, from superhighways in Appalachia where they can't afford cars to drive on them to seaports in places like Oklahoma where stevedores never go out on strike, from idiocy at the Bay of Pigs to apparently rank dishonesty in Indonesia.

And mistakes cost money. In that our Defense expenditures *nearly* outweigh all others and the sharpest business mind in the bureaucracy is running that show, it is reasonable to expect the economy pressure to be heaviest where it has some chance of showing results. The "Administration," therefore, looks to Mr. McNamara to produce the kudos it finds so hard to generate anywhere else. I think he is more to be pitied than censured if his judgment slips a cog now and then. After all, a higher authority probably said: "They had their best year last year. Let's try it."

W. Lawrence Eccles, Jr.
South Pasadena, Calif.

Parker
METAL V-SEAL
A RELIABLE WEIGHT REDUCING SEAL FOR EXTREME ENVIRONMENTS

Today's engineer must cope with such environments as temperatures ranging from −423°F. to plus 2000°F., from hard vacuum to high pressures, and exposure to extremely volatile and corrosive media or radiation. Parker's Metal V-Seal represents a significant achievement in the search for an effective, economical and weight reducing static face seal to meet these extreme demands . . . Designed, engineered and made to Parker's high standards of quality and dependability.

BASIC ADVANTAGES:
- High resistance to corrosive and volatile chemicals
- Low flange loads to minimize system weights
- High resiliency to compensate for flange deflections
- No special flange machining required (can be made to fit almost any existing groove and **some styles do not even need a groove!**)
- Reusable several times under most conditions
- Wide variety of seal metals, platings, and coatings to meet specific requirements
- Full range of standard sizes from ¼" to 15" O.D. (Larger on special order)

Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio

Want more information? Send for Catalog 8800

Circle No. 2 on Subscriber Service Card

Solid Sophistication

To the Editor:

The proponents of solid rockets have performed on the industry and the public, a bit of sly salesmanship which I see that the editor of MISSILES AND ROCKETS has now also fallen for. By your Jan. 11 editorial ("Paper Bear") describing the *Minuteman* and *Polaris* missiles as smaller, quick-reacting solid-propellant missiles, which they are, the impression has been created that only by the use of solid propellants can we build small, quick-reaction missiles. Of course, the use of solid propellants makes the missiles somewhat *larger* than they would be if liquid propellants were used. The reduction in size of *Minuteman* compared with *Titan II*, for example, is due to the reduction in the size of the warhead, not any solid-propellant magic. The payload-to-weight ratio of *Minuteman* is actually inferior to that of *Titan II*, for example.

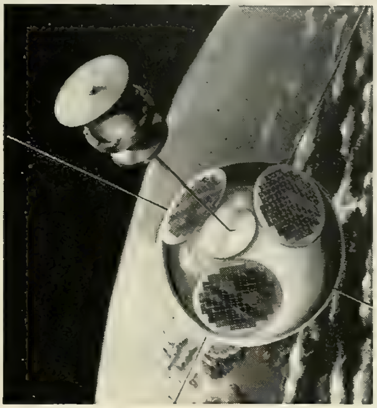
The slow reaction time of *Atlas* and *Titan I* is attributable to the use of liquid oxygen, which because of its cryogenic nature must be loaded into the missile tankage just prior to firing. All liquid propellants are not cryogenic, naturally.

I am surprised that so sophisticated a magazine as M/R would fall for this rather obvious bit of gamesmanship.

R. C. Truax
Fair Oaks, Calif.

We believe that the advantages, and disadvantages, of solids are so well-known to sophisticated M/R readers that no gamesmanship is required. Our ploy, Mr. Truax?—Ed.

Most attitude control systems have over 6000 parts



We made one with 15.

Before our Gravity Gradient Stabilization System with its one moving part came on the scene, it used to take some pretty complicated attitude control systems (with 6,000 to 8,000 parts) to do the job. And from the reliability standpoint, it looks as if our 15-element device can look forward to virtually unlimited life in space.

Boosted into orbit just about a year ago for the Naval Research Laboratory, it was working within six degrees of arc inside of 48 hours—and it's still operating! It's simple, easily manufactured and requires no power in operation.

More are due for the Navy. And for NASA we're designing a completely different configuration for their Applications Technology Satellite, where it will be a key factor in the many tests that this experimental satellite will undergo. Beyond that, we have some additional ideas of our own . . . its great potential for application to all types of meteorological, communication (both military and commercial), biological and other research satellite systems.

Looking at professional opportunities here, they range over both active and passive attitude control systems, and a number of other projects. The Spacecraft Department is the leader in studies of possible means of unmanned spacecraft exploration of planets of our solar system. For example—the early exploration of Mars (Mars 69-73). We are currently building the control and stabilization system for NASA's Orbiting Astronomical Observatory (OAO). We're continuing our work on the weather satellite Nimbus. Weightlessness, outer space travel, emergency ejection from orbit or spacecraft and life support systems are other problems that are receiving careful attention.

Our needs for engineers and scientists to work on both passive and active attitude control systems are pressing, as well as for some of our other current projects: GUIDANCE & CONTROL SYSTEMS ☐ GUIDANCE AND CONTROL ANALYSIS ☐ RELIABILITY & STANDARDS ☐ MEASUREMENTS & ENVIRONMENTS ☐ COMMAND & TELEMETRY DESIGN ☐ ELECTRONIC PACKAGING ☐ RF ANTENNA DESIGN ☐ ADVANCED MILITARY SYSTEMS ☐ ELECTROMECHANICAL & MAGNETIC COMPONENTS DESIGN ☐ STRUCTURES ☐ PROJECT ENGINEERING ☐ PRODUCIBILITY ENGINEERING ☐ PROCESS CONTROL ☐ THERMODYNAMICS ☐ RADAR DISCRIMINATION ☐ MATERIALS APPLICATIONS

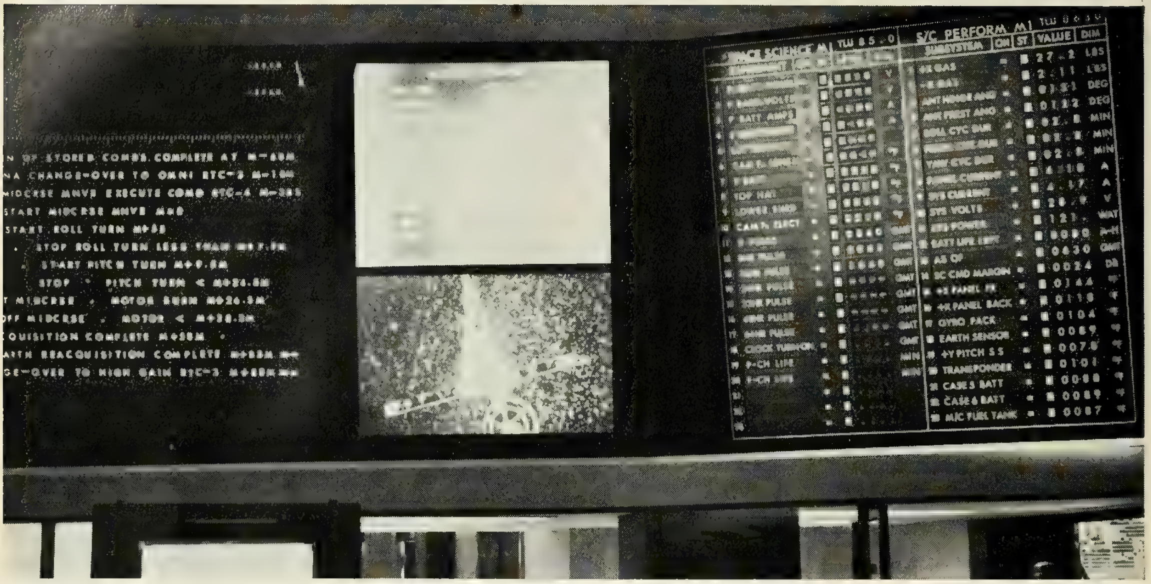
You are invited to inquire further by writing to: Mr. J. S. Barson, Room 94-J, Spacecraft Dept., Valley Forge Space Technology Center, General Electric Co., P.O. Box 8555, Philadelphia, Pennsylvania. An equal opportunity employer.

MISSILE & SPACE DIVISION

GENERAL ELECTRIC

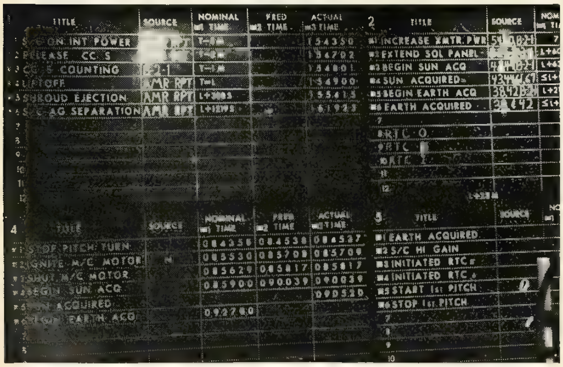
MOON-SHOT REPORT

CBS equipment helped provide mission status information to nearly every member of the Moon-Shot team at the Space Flight Operations Facility during the history-making flights of both Rangers — 7 and 8.

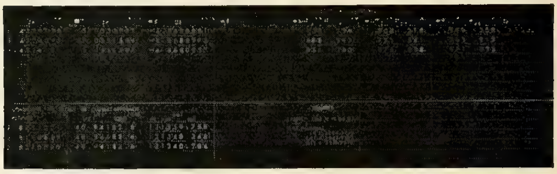


1. **Flight information status boards,** designed by CBS Television Operations, contain more than 4,000 digital display units originally developed by CBS Laboratories for use in CBS News election returns coverage.

3. **Closed circuit television** installation designed by CBS Laboratories transmitted data to selected scientists and engineers at push-button consoles. Status boards are specially designed for optimum camera pick-up.



2. **Incoming data from the Rangers** was processed by command center's computer system, then fed to flight status boards as letters, digits, symbols. Information is directly readable up to 65 feet.



4. **Conditions of many elements of operation** are displayed at the same time. Team members can request specific information to be televised on their own closed circuit screens.

CBS Laboratories served as consultants to Jet Propulsion Laboratory in the component specifications; and teamed with the CBS Television Engineering Department to assist in the installation and testing of the display and closed circuit television system of the Space Flight Operation Facility.

...serving the men who conquer space

CBS LABORATORIES Stamford, Connecticut
a division of Columbia Broadcasting System, Inc.

Circle No. 4 on Subscriber Service Card

The Countdown

WASHINGTON

NASA To Award AOSO Contracts

NASA expects to award contracts early in Fiscal 1966 for the *Advanced Orbiting Solar Observatory*. Total cost for two missions in 1969 and two in 1971 is expected to reach about $150 million. Republic Aviation will be named prime contractor. Two major subcontracts will be for the control system and telecommunications. These will go to members of the Republic team in the phase I study.

Substantial Asroc Procurement Planned

Asroc, the Navy rocket for delivery of an ASW homing torpedo or depth charge at long range against submarines, will continue to be procured in substantial quantities in FY 1966. This will bring stocks of this weapon up to the Navy's planned goal. The Navy also plans to buy a large number of the new MK-46 lightweight ASW torpedoes for use with *Asroc* and other delivery systems. Nearly $47 million is included in the defense budget for procurement of Dash drone ASW helicopters.

Ranger Spacecraft Arrives at Cape

Spacecraft for the *Ranger IX* flight is now at Cape Kennedy. NASA still hopes to get the launch off this month although only about three weeks remain before the window opens.

Navy Plans First Buy of Improved SAM

Navy plans to procure its first increment of the new "standardized" *Tartar/Terrier* missile with funds included in the $108 million request for the improvement of the *Tartar, Terrier* and *Talos* missiles under the SAM Improvement Program. FY 1966 funds are also included for continued procurement of *Talos*.

Problems Crop Up for GT-3

Beginning of final checkout of the *Gemini/Titan II* for the *GT-3* manned mission has revealed two early technical problems. An accelerometer in the inertial guidance platform has been registering a speed of about 50 ft. per second more than true speed. A baristat switch on one of the personal parachutes to be worn by the astronauts during the mission also appears to be malfunctioning. NASA has not indicated whether either of these would delay the flight, still scheduled for late March or early April.

Development of Re-entry Vehicle Forecast

One of the hoped-for fallouts in the Air Force *ASSET* program, according to Secretary of Defense McNamara, is development of a small lifting-body re-entry vehicle which could return military and scientific data from orbiting space craft to predesignated landing areas.

NASA Tracking and Data Costs To Drop

NASA spending for tracking and data acquisition will drop sharply in the new fiscal year primarily because the three new *Apollo* tracking ships are being funded from the FY '65 budget. The $246.2-million FY '66 request includes $102.4 million for new equipment and $129.3 million for operation of current systems. Budget request for this fiscal year was $274.7 million.

Pegasus Reports on Punctures

Nineteen punctures by meteoroids had been reported by the *Pegasus* detection satellite a week after its launch from Cape Kennedy. Ten of these were through the 1.5-mil-thick portion of the spacecraft, five through the 8-mil portion and four through the 16-mil portion.

Army Seeks Money for Hawk Spares

Although the Army contemplates no procurement of additional *Hawk* or *Hercules* surface-to-air missiles in FY 1966, a request to reprogram $34 million to procure *Hawk* equipment has been submitted to Dept. of Defense. To build up stocks of spares to more adequate levels, Army has earmarked $14 million of this amount, with another $8 million designated for certain high-value repair parts and for continuing modifications of *Hawk* missiles now in inventory.

INDUSTRY

Air Force Negotiates New Engine Contracts

Research and development contracts covering a new advanced liquid propulsion engine—embodying such previously funded components as high-pressure combustion, altitude-compensating nozzles and toroidal configurations—are being negotiated by the Air Force with two propulsion firms. The work will be monitored by the Rocket Propulsion Laboratory at Edwards AFB, Calif. The two contractors are Aerojet-General and Rocketdyne division of North American Aviation. Funding and specific engine details have not been disclosed yet, but major emphasis will be on storable liquid propellants.

MSF Network Award Goes to Bendix

NASA is negotiating with Bendix Field Engineering Corp. for a $36-million contract for operation, maintenance and support services for its Manned Space Flight Network tracking stations. Contract will run two years with annual options which could extend the award for three years more, thus covering both *Gemini* and *Apollo* space flight programs. Contract succeeds a present Bendix contract for support of the *Mercury* tracking net.

New Team Forms for Poseidon

Thiokol and Hercules teamed up for the *Poseidon (Polaris C-3)* rocket motor proposal to Lockheed Missiles and Space Co. In addition to the Thiokol/Hercules bid, proposals were made by United Technology, Aerojet and Rocketdyne. Lockheed is due to reply this week to the Navy with a proposal on the program definition phase of the new submarine missile.

INTERNATIONAL

France Discloses New Satellite

France has disclosed plans for a prototype satellite to be orbited prior to its first *Diamant* satellite, the *D-1*. The short-life experimental satellite will provide the first flight test of new airborne programmers using modular techniques which were developed for the *Diamant* space program. These are built by Laboratoire Central de Télécommunications (LCT), principal continental laboratory of the ITT Europe system for aerospace research and development.

Voyager Design Bidders

The Jet Propulsion Laboratory has received bids from seven firms on preliminary design study of the *Voyager* spacecraft. Initial phase of the program will consist of a three-month design definition using "several" competing contractors.

Responses were received from: Boeing (with Philco and Electro-Optical Systems on its team); General Electric Missiles & Space Div. (with Texas Instruments and Motorola); Lockheed Missiles & Space Co. (with RCA Astro-Electronics Div. and Avco).

Also: Martin Co., which is not part of a team but which is proposing Hughes Aircraft as guidance and control subcontractor; North American Space & Information Systems Div. (bidding alone); General Dynamics/Convair; and TRW/Space Technology Laboratories (with Eastman Kodak and Douglas).

California Tops DOD List

California continued to lead the nation in the number of prime DOD contract awards for the first half of FY 1965, with 21.9% of the total value of all contracts issued.

Procurement actions during the first six-month period totaled $10,312,402,000, with $4,695,012,000 worth of contracts awarded during the autumn quarter.

Ranking of the first 10 states with the total value of the prime contracts let in each during the first half of the current fiscal year showed: California, $2.263 billion; Texas $838.6 million; New York, $793.8 million; Massachusetts, $496 million; Pennsylvania, $448.5 million; Connecticut, $446.6 million; Florida, $421.9 million; Georgia, $413.5 million; New Jersey, $388.5 million; and Ohio, $353.4 million.

$130 M Sought for Sea Study

Total request for Naval oceanographic research during FY 1966 will be $130 million, with about 29% assigned to the Office of Naval Research, 34% to Naval Oceanographic Office, 37% to Bureau of Ships, and under 1% each to Bureau of Weapons and Bureau of Yards and Docks.

About half this money will go to the classified Navy program, with $67 million in the unclassified National Program. According to Rear Adm. Denys W. Knoll, commander of the U.S. Naval Oceanographic Office, the Navy now has 24 research and survey ships in operation, under construction or authorized. In addition it has provided 14 ships to institutions and universities for use in connection with Navy research programs.

In the FY '66 budget request, two research ships for use by Scripps and Woods Hole Institutions and a large coastal survey ship are being requested. In spite of all the new equipment, Knoll said, there will remain a deficiency of 9 ship-years for research and 30 ship-years for surveys.

Comsat Launcher Proposals

Communications Satellite Corp. is evaluating proposals from five firms for study of launcher vehicle for medium-altitude communications satellites.

Companies submitting bids out of 16 firms requested were Boeing Co., Douglas Aircraft Co., Inc., General Dynamics, Lockheed Missiles & Space Co., and Martin-Denver.

The evaluation will be completed sometime next month. The study contract, worth from $300,000 to $500,000, will be awarded later.

Overland ICBM Shot Set

The *Minuteman* test firing scheduled March 1, weather permitting, from an ICBM operational silo launch site 10 mi. north of Newell, S.D., will be the first instance of an intercontinental ballistic missile launch from any point in the United States other than Cape Kennedy or Vandenberg AFB.

Scheduled to return to Earth about a mile from its launch point, the specially prepared missile will contain only enough live propellant to sustain several seconds of powered flight. In other respects, the countdown and launch is planned to simulate an operational firing by Air Force crews.

Shots of the Week

The Soviet Union lofted four satellites in two successive days, a triple-header on Feb. 21 followed by another single shot on the 22nd. The unmanned instrumented satellites, *Cosmos 54-57*, were said to be functioning normally. The first three are orbiting near each other at nearly common apogees (of 1,150 mi.), perigees (173 mi.) and periods (106.2 minutes).

- The Air Force on Feb. 23 launched an *ASSET* research vehicle aboard a *Thor-Delta* booster (see p. 12). Shot was from Cape Kennedy.

ASSET Follow-on Considered

A large payload re-entry test vehicle, a follow-on to the 1000-lb. early *ASSET* payloads, is being considered by the Air Force.

Thirty-nine firms have received RFP's for a study, which are due later this month. Firms receiving the RFP's include: Philco Corp., Aeronutronic div., AMF, Atlantic Research, Bell Aerosystems, Bendix, Boeing, Bunker-Ramo, Chrysler, Defense Research, Douglas Aircraft, Dynamic Science, General Dynamics, GE, Grumman, Honeywell, Hughes, IBM, ITT, Lear Siegler, LTV, Lockheed Missiles and Space, Marquardt and Martin.

Also, McDonnell, North American Aviation, Northrop Nortronics, Pan American World Airways, Planning Research, RCA, Ralph M. Parsons, Raytheon, Space-General, Space Systems, Inc., Sperry Gyroscope, TRW/STL, Thiokol, United Aircraft, Western Electric and Westinghouse Electric.

Better Ranger Pix Possible

A doubling of *Ranger* picture resolution is being gained by use of a computer program developed at the Jet Propulsion Laboratory by Dr. Robert Nathan.

Picture data are taken directly from magnetic tape and digitized for insertion into an IBM 7094. This bypasses the kinescope response that is one source of distortion in the published *Ranger* pictures.

Calibration data obtained in the computer before the *Ranger* flight is used to take out noise and distortion. Then various map projections can be produced, three-dimensional contour maps can be drawn, and an automatic analysis of the area for spacecraft safety can be carried out.

This technique has been developed for a production program that will be applied to the last 20 frames of all six cameras in each of the three *Ranger* television missions. During the period in which the present programs were developed, about 15-20 P-frame pictures have been processed.

Each line in the P-camera pictures is split into 300 elements during the digitizing process. Removal of noise from one frame may take about three minutes on the 7094; other programs are generally shorter. A typical total time for processing one frame completely is about 10 minutes. When full-time pictures are processed, they will be broken down into 16 part-frames.

Removal of noise from the pictures brings "a dramatic increase in resolution," says Nathan. Craters become visible that were not seen in the original pictures.

Beryllium Motor to Thiokol

Two solid rocket motors containing high-energy beryllium additives will be designed, fabricated and delivered to the Air Force Ballistic Systems Div. by Thiokol Chemical Corp.'s Wasatch Div.

The $800,000 contract calls for both motors to be loaded with about 4,000 lbs. of beryllium-containing propellant. The units will be 55 in. across and 60 in. in overall length.

The program is designed to gather data on ballistics, nozzle erosion and other motor performance results. High-density graphite, pyrolitic graphite and tungsten nozzle throat materials will be evaluated during the test firings. All tests will be conducted at Edwards AFB, Calif., and are expected to be the largest beryllium motors fired to date.

The motors will be processed at Thiokol's high-energy propellant plant located in the R&D area near Air Force Plant 78—the *Minuteman* first-stage production facility operated by Thiokol in Utah.

DOD Comsat Launch Next Year

The Air Force *Titan III-C* booster will launch the first cluster of eight satellites for the military comsat system into an 18,000-mi. random equatorial orbit in February, 1966, if present schedules hold.

Brig. Gen. Joseph Bleymaier, Systems Command deputy commander for manned systems, indicated that the entire group of 24 communications satellites will be orbited by mid-1966, with two more eight-payload launches planned for April and June of next year.

First orbit of an advanced, longer-lived system is planned during FY 1968, Bleymaier said.

Meanwhile, the Army Electronics Command, Ft. Monmouth, N.J., has issued RFP's for design, development, fabrication and installation of a satellite communications facility. It also includes development of operational procedures for area and Earth station control functions, ancillary items and technical reports. Proposals are due in about two weeks.

WTR Facility Will Cost $5 M

A *Delta* launch facility at the Western Test Range near Lompoc, Calif., to support the *TIROS Operational Satellite* (*TOS*) program is expected to cost nearly $5 million, DOD spokesmen say.

NASA and DOD have formally agreed to establish the new facility, adapting it from existing Air Force *Thor-Able Star* installations where possible, with both agencies sharing construction costs. Completion is planned during the first part of calendar 1966.

The Pacific coast location will eliminate the need for launching in a dog-leg trajectory from Cape Kennedy to attain the near-polar orbits required. Other satellites destined for eventual launchings from the new *Delta* facility include: atmospheric structure and other scientific *Explorers*, ultimately geodetic *Explorers*, and also the Canadian-American *ISIS-X* (beginning in 1967).

DCA Rejects Comsat Bid

The Defense Communications Agency has rejected a proposal by Communications Satellite Corp. to provide services for the Initial Defense Satellite Communications project.

The corporation said it was informed that DOD had concluded its present program was "superior" to that proposed by Comsat. The Comsat plan had called for providing DOD with 24 ICSS satellites. The Defense Dept. would have paid only for service rendered following launch.

The announcement thus ended Comsat action to award a letter contract for work on the proposed system. The corporation originally planned to make the $100,000 award to Hughes Aircraft Co. in January, but was delayed when the Federal Communications Commission ruled it must consider proposals from other interested companies.

Button New Comsat Exec

Robert E. Button has been named executive assistant to Communication Satellite Corp.'s chairman and chief executive officer Leo D. Welch.

For the past six years, Button has been a counselor to the U.S. Regional Mission to NATO and OECD in Paris.

ENGINEERS
PHYSICISTS

POLARIS
SYSTEMS
EVALUATION

The Applied Physics Laboratory, The Johns Hopkins University, has several immediate openings for qualified engineers and physicists to participate in pre- and post-patrol evaluation of the Polaris weapon system. Working in close association with Naval operational personnel, APL staff members develop test objectives, establish test procedures, and monitor tests at Cape Kennedy and aboard submarines. Particular emphasis is placed on the analysis of test data and the development of recommendations for improvements in system and sub-system performance. New staff members are normally assigned to a sub-system area, such as Missile, Fire Control, Navigation, or Launcher, with later opportunities for broader system assignments based on experience and knowledge. A degree in physics or electronic engineering and experience in one of the above areas are preferred.

The Applied Physics Laboratory's location in suburban Washington, D.C., gives you a choice of city, suburban, or country living. The area offers many benefits including excellent residential areas, complete service and recreational facilities, and good public and private schools. There are seven universities at which staff members can continue their education with APL financial support.

Direct your inquiry to:
Mr. W. S. Kirby
Professional Staffing

Applied Physics Laboratory
The Johns Hopkins University

8643 Georgia Avenue
Silver Spring, Maryland
(Suburb of Washington, D.C.)

An equal opportunity employer

Circle No. 3 on Subscriber Service Card

In Congressional testimony . . .

NASA Promises 'Versatile' Voyager

Fresh details of FY '66 plans outlined; House committee members voice concern over deletion of M-1, SNAP 8 and 260-in. programs

by Heather M. David

THE *VOYAGER* PROGRAM for which NASA is asking funds this year will provide a spacecraft which could conduct all the unmanned exploration of the solar system for the near future, reports Dr. Homer Newell, Associate Administrator for Space Sciences.

Newell told the House Science and Astronautics Committee in posture hearings that the spacecraft will be "versatile and flexible" and designed to study physics, chemistry and astronomy in the entire solar system, as well as extraterrestrial life.

He detailed—after the primary mission of Mars—Venus, the moons of Jupiter and Saturn, Mercury, the outer planets and comets and asteroids as candidates for future *Voyager* programs. Fiscal Year 1966 funds would provide for a design definition effort with detailed system design plus breadboard subsystems. A decision would have to be made with the FY '67 budget to proceed with flight hardware.

The hearings were the first round of the annual scrutiny of the NASA authorization bill, in which NASA submitted a budget characterized by Administrator James E. Webb as a "some opportunity" budget. He said the 1969 lunar date now can be met only if the landing mission is accomplished before the 15th *Saturn V* flight as planned.

• **Missing programs**—Both sides of the aisle in the House "space" committee showed considerable concern over the deletion from the budget of the SNAP 8, M-1 and 260-in. solid motor programs. Republican and Democratic members alike questioned NASA on the reasons for the deletion.

Chairman George P. Miller (D-Calif.) indicated that the protest against cancellation of these programs should be registered "at another level" rather than with NASA. Congress has in past managed to get funds for programs such as flight test of the SNAP 10A, when the Administration decided to drop them. NASA witnesses made it clear that these programs were cut by the Budget Bureau and the President.

Rep. Ken Heckler (D-W.Va.), chairman of the subcommittee on advanced research which will review these programs, said he was "disturbed at the progressive declines in the Office of Advanced Research and Technology's requests." OART's total was $536 million in FY '64, $519 million in '65, and $475 million for FY '66. The '66 budget also has increased its administrative operations portion, while its R&D has decreased further.

Bisplinghoff told the committee that he hoped "to return to a higher level in future years," and that he recognized that under stringent budget levels some of the other programs had priority. The differences in the budget for these years, he also indicated, were directly related to these deleted programs.

• **Space Sciences**—In other testimony during the first summation of NASA's programs, Dr. Homer Newell disclosed that the navigation satellite study will emphasize air navigation and traffic control.

In communications, he said, the goals would be to improve the technology of the systems and make possible direct broadcast from satellites to home receivers. Webb, in opening testimony, said that he felt that the direct-broadcast satellite was one which the Soviets might feel was a major goal.

• **OART**—Among important projects listed were a re-entry experiment on a *Scout* rocket, which will evaluate a phenolic nylon heat shield that Bisplinghoff said shows great promise. Another flight planned is a small rocket to provide velocities up to 90,000 feet per second for simulation of meteors.

Work also will contine on an aluminum spacesuit which is being developed by Litton Industries (M/R Aug. 24, p. 22). Bisplinghoff said the suit offers considerably more mobility and meteoroid protection than do current soft suits. NASA also is working on a flight experiment which will measure the function of the inner ear in balance in orientation, he said.

• **Tracking**—New tracking facilities requested in the budget included two transportable stations in the Manned Space Flight Network, to be located in the Grand Bahamas and Grand Turk Island, and standard Unified S-Band equipment with a 30-ft.-dia. antenna for existing stations at Antigua and the Grand Canaries, according to Gerald Truszynski, Deputy Director of Tracking.

• **Contracting**—NASA's request to fund 20 additional contracting positions to staff regional consolidated contract administration offices established by the Department of Defense (Project 60) came under some questioning.

Rep. James G. Fulton (R-Pa.) questioned the move on the basis of need, concentration of facilities, and correctness. Chairman Miller indicated that this, and other such matters should be taken up by the NASA Oversight subcommittee, if members so wish.

Progress in placing procurements competitively was reported by NASA, which said that in the first six months of this year 68%—or $1.6 billion—was competitive.

Incentive contracting has increased also. By Dec. 31, 1964, there were 75 contracts with a target value of $751 million, Deputy Associate Administrator for Industry Affairs George Friedl said. At present, there is over $1 billion in these contracts. By the end of this calendar year, he said, NASA hopes to have at least 105 incentive contracts with a target value of approximately $2.5 billion.

Letter contracts also have been decreased, from an aggregate $574 million at the end of FY 1963 to only $4 million at the end of January. These are to be definitized by March.

NASA also is asking for authorization in this bill to enter into two-year service contracts, so that contracts of this type do not all terminate at the end of each fiscal year. Friedl said DOD is now operating with such permission and has found that it greatly improves its work. Service contracts now only may be signed for the duration of the fiscal year, making it necessary to rush through extensions or new contracts for additional time. ■

Slated for Tuesday . . .

Centaur Ready for Critical Launching

First payload ever to be boosted by unique vehicle will be model of Surveyor spacecraft, in rehearsal for later Moon missions

by Hal Taylor

A MAJOR STEP in the development of the *Centaur* booster is scheduled this week when an attempt will be made to orbit the first payload boosted by the liquid hydrogen/liquid oxygen-powered vehicle.

The payload will be a dynamic model of the *Surveyor* spacecraft, which *Centaur* is designed to loft toward the Moon on soft-landing picture-taking missions in 1966. If successful, the flight—scheduled for no earlier than March 2—will place the *Surveyor* model into a highly elliptical orbit with an apogee of 500,000 miles and a perigee of about 100 miles.

Another significant flight objective is that the *Centaur* will be flown on a simulated lunar transfer trajectory until the propellants are depleted or until full lunar transfer power is achieved and the guidance system cut-off is accomplished.

The fifth flight in the *Centaur* development program also marks the first time that it will be boosted by an uprated *Atlas* propulsion system and the *Centaur* upper-stage propellant utilization system.

- **Dummy Surveyor**—The *Surveyor* dynamic model is a dummy space frame ballasted to simulate the dynamic response characteristics of the *Surveyor* flight spacecraft. Use of the model will provide data on the interaction between *Centaur* and its payload during the crucial phase of the flight just prior to injection into orbit.

For the mission, the *Atlas* booster will be equipped with up-rated first-stage engines developing a thrust of about 165,000 lbs. each, a sustainer engine with 57,000 lbs. and two vernier engines developing 1,000 lbs. each.

The *Centaur,* powered by two RL-10 engines, develops a thrust of 30,000 lbs.

The *Surveyor* model consists of a space frame supplied by the Hughes Aircraft Co.—prime contractor for the *Surveyor* spacecraft—and a retro-motor simulator assembly built by General Dynamics/Convair. It is similar to the actual spacecraft except for certain reinforcing structures which are deleted from the model. Dummy masses are mounted on the spaceframe to simulate the mass properties of those items they replace. The planar antenna, solar panel, and mast assembly are similar in appearance to their *Surveyor* counterparts, and there is a simulated *Surveyor* landing gear. The dynamic model weighs about 1,400 lbs. compared to the 2,250-lb. weight of a flight *Surveyor.*

- **Flight record**—*Centaur* accomplished the first known successful flight of a vehicle using liquid hydrogen as propellant on Nov. 27, 1963. Following its first success, the upper stage has been flown twice—on June 30 and Dec. 11, 1964.

The June 30 mission accomplished five of its six primary objectives. Premature shutdown of its hydrogen engines resulted in a shorter-than-planned burning period.

The Dec. 11 flight was a complete success, accomplishing all of the mission objectives including the first use of its inertial guidance system to control the stage following booster shutdown, but also to perform in-flight maneuvers.

The first flight in the series, on May 8, 1962, was a complete failure when the *Centaur* exploded prior to separation from the *Atlas* booster.

Convair division of General Dynamics Corp. is the prime contractor for the *Centaur* vehicle, including the *Atlas* booster. Grant L. Hansen is the firm's *Centaur* program director and a vice president of GD/Convair.

Pratt & Whitney is an associate prime contractor for *Centaur's* RL-10 hydrogen engine. Gordon Titcomb is the firm's project manager.

Honeywell Inc., St. Petersburg, Fla., is an associate prime contractor for the stage's inertial guidance system. H. B. Foster is program manager. ■

Webb To Spell Out Program Phase-outs

NASA ADMINISTRATOR James E. Webb is expected to send a letter to Congress in the next few weeks spelling out a plan to phase out the big solid motor, M-1 engine, and SNAP 8 programs.

It is believed that Administrator Webb may ask Congress to provide up to $10 million in Fiscal Year 1966 funds to continue the 260-in. solid motor program up to the point of firing one half-length motor.

NASA officials believe this is the only way that useful information will be obtained from the funds poured into the program in previous years. If this is not done, they have told Webb, almost no useful data at all will be obtained.

Previously, the NASA program had called for firing two of the half-length motors and eventual firing of a full-length motor.

As far as the other projects are concerned, both the M-1 and SNAP 8 can be phased out by using FY '65 funds and no additional authorization is expected to be requested.

In the M-1 program, it is hoped that tests of the oxygen pump and the thrust chamber can be completed. In the SNAP 8 project, NASA wants to test the unit to as close to a 10,000-hour-duration run as is possible.

There have been reports that members of Congress have suggested to NASA that it continue the programs in Fiscal '66 by reprogramming funds authorized for other projects. A NASA official points out, however, that the original decision to cancel the projects was a budgetary one and this has not changed.

There is still hope within the agency that the space committees of both houses of Congress will add funds for the three programs to the 1966 budget.

Lost ASSET Bore Important Data

Paint and refractory metal experiments lost; telemetry indicated good flight; older vehicle may be re-flown

A QUICK GLIMPSE on aircraft radar was the only return other than radio signals received from the sixth *ASSET* re-entry vehicle launched from Cape Kennedy Feb. 23.

An Air Force tracking aircraft picked up *ASSET ASV-4* just before it impacted in the South Atlantic, off the east coast of South America an estimated 2,390 n. mi. southeast of its launch point. The search for the vehicle was called off on the afternoon of the 24th.

Early telemetry reports from Cape Kennedy indicated that *ASV-4* performed as planned during flight. A velocity of 19,500 ft. per sec. was apparently reached and the spacecraft attained an altitude of 205,000 ft. The planned 20-degree angle of attack was achieved and the vehicle reached the Mach-20 speed programed.

Failure to recover the vehicle lost important data which would have been derived from a temperature-sensitive paint experiment carried on the outside surface and on the interior of *ASV-4*. Thousands of ¼-in.-dia. dots in 10 different colors were stenciled on various surfaces of the vehicle to indicate heating effects in terms of the temperature at which the various colors change.

Heat-induced color changes were programmed to occur in 150° increments over a temperature range of 1,400° to 2,900°F. The shades and hues included in the polka-dot color scheme included all basic colors except red. The paints, covered with a protective coating to prevent oxidizing, covered about 50% of the *ASSET'S* outer surface. Paint dots located on the inside of the vehicle would have afforded an opportunity to check the insulating properties of the exterior shell.

- **Lost specimens**—Two small gold-plated holders attached to the back of the vehicle carried 12 refractory metal specimens—six in each countainer—each metal tab measuring about 1 X 1½ in. One container held thoria-deposited nickel, tantalum, coated colombium and three "defect columbium samples. The tabs had been coated and then scratched or rubbed in order to test the reaction of the metal beneath to various degrees of defects.

More heavily protected samples—of molybdenum, tungsten and columbium—were carried in the other receptacle, along with three defect specimens. The materials tab test replaced Bell Areospace Systems insulated and cool panels used on previous flights. Prepared by Martin Co., the columbium sample material was described as a "brazed honeycomb sandwich panel."

Air Force and industry technologists, however, indicated that telemetry returns provided quantities of valuable data about other aspects of the flight.

- **Firing good**—Launch was at 9:36 a.m. EST, with first stage engine cutoff 160 seconds later. The second stage fired after a 4-second delay and cutoff was 243 seconds later. Payload separation was achieved, sending *ASSET* into a long coasting glide, with the drogue parachute opening at T plus 1,323 seconds. Main chute opening occurred at T plus 1,402 seconds. The brief appearance of the vehicle on the radar of one of the tracking aircraft appeared at about this point in the time sequence.

Preliminary indications were that all flight and glide requirements were met. After a late start in the initial countdown, two holds occurred—the first at T minus 8 minutes for a radar difficulty at Antigua tracking station, lasting 20 minutes. After recycling to minus T 20 the countdown was halted again when it reached T minus 8.

- **Followed successes**—The third *ASSET* test last July was completely successful, including recovery. No attempt was made to recover test shots four and five. The Air Force considers four of the previous five tests successes, although only one was recovered. Following is a summary of earlier launches:

ASV-1: velocity, 16,093 fps; altitude, 203,377 ft; angle of attack, 38 degrees; range 987 n. mi.; maximum Mach, 16.5; launched Sept. 18, 1963; lost in recovery attempt.

ASV-2: velocity, 18,000 fps; altitude, 196,000 ft.; angle of attack 20 degrees; intended range, 1,857 n. mi.; maximum Mach, 18; launched March 24, 1964; experienced *Delta* booster failure.

ASV-3: velocity, 18,000 fps; altitude, 215,000 ft.; angle of attack, 38 degrees; range, 1,400 n. mi.; maximum Mach, 19; launched July 22, 1964; successfully flown and recovered.

AEV-1: velocity, 13,000 fps; altitude, 166,500 ft.; angle of attack, 20 degrees; range, 832 n. mi.; maximum Mach, 12.5; launched Oct. 27, 1964; no recovery attempted.

AEV-2: velocity, 13,000 fps; altitude, 184,300 ft.; angle of attack, 26 degrees; range, 780 n. mi.; maximum Mach, 12.5; launched Dec. 8, 1964; no recovery attempted.

The low, 20-degree angle of attack, plus the long 2,390-n. mi. trajectory (longest in the six-launch *ASSET* series to date) will afford scientists new data on the longest, flattest glide possible through the Earth's atmosphere for the vehicle—at the highest mach number.

Maximum heating expected during the flight for a variety of materials and metals in the *ASSET* vehicle included: the molybdenum nose skirt—3,000 degrees F.; the zirconium oxide nose cap—4,000 degrees; colombium in the aft panels—between 2,800 and 2,900 degrees. L-605, a cobalt-based super alloy on the upper surface was not expected to reach a temperature above 2,100 degrees F. and the graphite leading edges were expected to reach 3,000 degrees.

AF spokesmen at Cape Kennedy said consideration will be given to re-flying the *ASV-3* vehicle since *ASV-4* was not recovered. ■

In posture statement . . .

McNamara Says MOL Awards Are Near

Observers believe three prime contractors may be selected as early as this week; a service-by-service report on message

by Donald L. Zylstra

PROPOSALS OF THREE of seven firms in the contest for the *Manned Orbiting Laboratory (MOL)* will be selected by the Air Force for preliminary design studies, following presentation at Space Systems Division headquarters in Los Angeles.

Fiscal Year 1965 money will be used for funding the three studies and 60 days will be allowed for their completion, following selection of the contractors and negotiation of the contract. Some Washington sources look for selection of the three prime contractors as early as the beginning of this week.

In his posture statement to the House Armed Services Committee, Secretary of Defense Robert S. McNamara noted that the three-contractor competition is expected to determine how well a proposed *Gemini B*-laboratory-*Titan III-C MOL* system might meet broadened military requirements. Under terms of the three contractor studies, it also is apparent that the Air Force would like to have an opportunity to examine a proposal that employs *Apollo* hardware—both the initially approved configuration for the lunar program and modified Apollo configurations aiming at affording 30 days instead of a minimum of 10 in Earth orbit.

After the preliminary design studies are completed and evaluated, the Air Force plans to narrow the *MOL* competition to two prime contractors "to be selected in FY 1965" who will be awarded program definition studies. The prime contractor surviving this final runoff will be selected as the sole prime for full-scale development.

The program definition studies will be supported from the $150-million *MOL* funding request for FY 1966.

R&D people in both the Air Force and DOD have emphasized that all of the three contractors in the preliminary design competition will be selected with the understanding that whichever survives the ultimate elimination must be fully competent to carry out full-scale *MOL* development. "No new hardware should be developed unless necessary," McNamara told the House committee.

- **The lineups**—Of the seven contractors submitting *MOL* proposals, only two did not specifically list other firms teaming with them in the bid for the design contract. North American Aviation and the Martin Co. were the two primes not listing associates. The other five and their associated companies include: The Boeing Co.—with Hughes Aircraft Co., Philco Corp. and Honeywell, Inc.; Douglas Aircraft Co.—with IBM, Raytheon Co., Collins Radio Co. and Sperry Rand Corp.; General Dynamics/Convair—with TRW Space Technology Laboratories; General Electric Co.—with Republic Aviation; Lockheed Missiles and Space Co.—with McDonnell Aircraft Corp., RCA, General Precision Instruments and AiResearch.

Air Force funding participation in the NASA *Gemini* effort through the DOD "*Gemini* (Manned Space Flight)" program will be completed with a FY 1966 request for a final $2 million, McNamara said.

Phoenix Holding Up F-111B Development

THE *PHOENIX* MISSILE development program, for which $71 million in FY 1966 funding is requested, was given the blame for a previously unannounced stretchout in the Navy's F-111B development.

"Last year we planned to procure our first increment of F-111B's in FY 1966," Secretary McNamara testified. "We have however encountered some development problems with the *Phoenix* missile. Since the system must be incorporated into the airplane, we have had to slip the aircraft production schedule and reduce the FY 1966 buy. Despite the delays in the *Phoenix*, we still plan for the first squadron for F-111B's to be operational on the previously scheduled date."

Noting that $1,670 million of the FY 1966 defense budget is earmarked for space effort, McNamara in his military posture statement described military participation as "an integral part of the much larger National Space Program"—for which expenditures now total about $6.5 billion annually.

- **Detection funded**—For systems and devices for detecting nuclear detonations worldwide, the *Vela* effort is requesting $59.3 million. *Vela* is part of an overall program of nuclear testing and test detection for which DOD is requesting $243.2 million. Of this amount, $28.5 million is for underground testing and $53 million for laboratory research on nuclear weapons effects.

For maintenance of a stand-by atmospheric test capability as a third safeguard in connection with the Nuclear Test Ban Treaty, the defense budget requests $47 million. Only $3.7 million additional in military construction funds is requested in FY 1966 for completing installations on Johnston Island in the Pacific, for which an earlier total of $41 million was allocated in the fiscal periods 1963 through 1965.

For monitoring of Sino-Soviet nuclear actions, the United States is promoting two programs to safeguard its position under the ban treaty. A total of $114.5 million has been requested in FY 1966. These efforts include the Advanced Research Projects Agency's *Vela* program and the Atomic Energy Detection System. The space-detection portion of *Vela* became operational with the placing of two "nuclear test detection spacecraft" in 55,000-n.-mi. orbit in October, 1963. A second launch of two satellites was accomplished in July, 1964, and all four satellites are currently operational and affording high altitude and deep space protection.

For *Vela* underground detection, 500 detectors are being placed in an area 150 by 100 miles in eastern Montana (M/R, Feb. 22, p. 24). This ground detection array is scheduled to go operational in FY 1966.

In FY 1964, DOD began a $100-million program of modernization and expansion of the Atomic Energy Detection System (AEDS). The present system represents a $55 million investment. About $34 million of the up-dating work was funded in the FY 1964-65 budgets and another $13.6 million is requested in FY 1966.

- **Space lead?**—McNamara estimates that the U.S. presently appears to be "far ahead of the U.S.S.R. in the application of space to military purposes." In discussing apportionment of the military space budget he noted that "about one-half of the Defense space effort is directly associated with unmanned military uses of space" such as vehicles and systems for weather, observation, communications, geodesy and navigation, with many U.S. programs in these fields now operational.

The other half of the space budget "is devoted to the creation of technology for future applications, i.e., exploratory and advanced developments," McNamara said.

Noting that the Communications Satellite Corporation's international agreements make an agreement providing for handling military traffic "incompatible," McNamara reviewed DOD's decision to resume development of its own military system, which is scheduled to be "launched and ready for use in early calendar 1966."

- **Cheaper comsats**—The original plan for launching the communications satellites into medium-altitude polar orbits with *Atlas/Agena* probably will be discarded in favor of using *Titan III-C*.

"We believe we can launch the entire system of 24 satellites into a high but random equatorial orbit with just three launches of eight satellites each," McNamara said. "This change will also greatly reduce the complexity and cost of the required ground environment. We now believe we can achieve a better system, at a cost $70 million cheaper than the one previously envisioned. The design objective for average operating life expectancy of the satellites in the initial system is three years with an assured minimum of 1.5 years.

"Concurrent with the development of the initial system, studies are being conducted to determine the operational and technical characteristics required for a more advanced and longer-lived system, which may be available for launch in FY 1968."

For the initial military communications satellite system, Army is requesting $2 million for further development of ground stations, Navy's portion of the system will cost $9 million, and $3.5 million will be needed for overall systems management equipment, the responsibility of the Defense Communications Agency. These sums are in addition to $18 million budgeted for the system in prior fiscal years.

Although Navy's navigational satellite system has been operational since July, 1964, FY 1966 budget requests for this program total $22.9 million. Navy is asking $7 million of this total for research to improve the life and reliability of the satellites and the remaining $16 million for annual operating costs, including purchase of launch vehicles to replace inoperative or dying satellites.

Navy's geodetic tracking system (Project *ANNA*) is listed for the major share of a $10.6-million funding request in this area, with $3.6 million requested to support space-related elements of Army's mapping and geodesy program.

The *Titan III* development program, scheduled for completion in June, 1966, has been stretched out to June, 1967, "to assist in maintaining a *Titan III-C* production and launch capability for the various user programs which will not require the *Titan III-C* until calendar year 1967," McNamara said. "It will not affect the three initial defense communication satellite payloads currently assigned to three of the *Titan III-C* development flights."

- **Start**—Re-entry and Recovery (START) projects are funded at $35 million in the FY 1966 budget. Among these is the *ASSET* glider (see p. 12), a 1,000-lb. winged vehicle for exploring the Mach 2-Mach 20 flight regime. *Thor* boosters lift *ASSET* to 200,000-ft. altitudes and impart speeds of 13,000 to 19,000 ft. per sec. Six launches, including "four highly successful re-entry tests" have been made to date.

"We hope this project will ultimately lead to the development of a small lifting body re-entry vehicle which could return military and scientific data from orbiting space craft to predesignated landing areas," McNamara said.

- **R&D breakdown**—In his posture statement discussions of defense research and development, McNamara divided the overall program into five categories: research, exploratory developments, advanced developments, engineering developments, and operational systems development. The first three are related to the development of new technology within DOD; the last two have to do with work toward incorporating this technology in an operational military system.

Military research, carried out by DOD's in-house laboratories and in an extensive program of funded research in the nation's universities, commands a total of $387 million in budget requests—10% more than in FY 1965. Much of this increase reflects rising research costs. For exploratory development, $1,142 million has been requested —$10 million more than in FY 1965.

Army's $254-million share includes work in applied research in rocket propellants, improved power sources and energy transformation and improved ground surveillance and target acquisition. About one-third of Navy's $342-million share will be devoted to ASW problems. A quarter of the Air Force share, totaling $316 million, is to be devoted to space or space-related subjects.

- **ARPA projects**—ARPA, which will get $230 million of the exploratory development request, plans to use $127 million in support of its Project Defender. ARPA's Project PRESS (Pacific Range Electromagnetic Studies) will continue to observe full-scale missiles during re-entry, from an experimental station on Roi-Namur Island in the Pacific. Other important funded tasks for ARPA include improved signal processing techniques for over-the-horizon radar systems, development of high-acceleration propulsion, and new optical techniques, including use of lasers for satellite detection. About $27 million has been applied to over-the-horizon radar development through FY 1965.

The advanced development category has been expanded from requests totaling $572 million in FY 1965 to $828 million in FY 1966—to provide development of experimental hardware with great latitude in meeting performance requirements, "thereby encouraging innovation," McNamara said. "Both the over-the-horizon radar and the anti-satellite systems were developed in this category but turned out to be easily convertible to operational systems," he observed.

- **Army**—Listed among Army's advanced development programs are: a command and control information system (CCIS) for field use, for which $13 million is requested, and an advanced air defense system (*AADS-70* or a related effort) which is slated for system definition studies in FY 1966.

- **Navy**—Navy is requesting $12 million for more work on its "*Advanced SAM* System" designed to eventually replace *Terrier*, *Tartar* and *Talos*, and will also continue work on the Advanced Anti-radiation Missile System, for which $6 million is requested. Another $5 million is listed for support of the Advanced Sea-based Deterrent effort, to investigate configurations of future sea-based deterrent systems.

Navy also has plans for $121 million worth of ASW development in this category, including: $5 million for Artemis/underwater acoustics, for long-range active detection of enemy submarines; $4 million for Trident; and $21 million for airborne ASW detection

Swedes Buy Saab 08 Missile for Destroyers

SWEDISH NAVY has placed a $16.5-million order with Saab Aircraft Co. for this new missile system, called 08, a development of the French target missile CT 20. Saab says the 08 will be used primarily on destroyers, increasing range and hitting power of invasion defenses. Both Swedish and French firms are taking part in development of the jet engine-powered missile, which is approximately 18 ft. long and has a wing span of about 10 ft. (4½ ft. with wings folded to increase shipboard storage capacity).

systems to counter high-speed, deep-diving submarines.

No funding totals are listed for two other ASW projects—Advanced Submarine Sonar Development, a passive system with "vastly increased performance" and Advanced Surface Sonar, involving two major efforts: 1) a sonar with passive and active detection features many times better than present equipment and 2) increased detection, range and classification capabilities for the existing AN/SQS-23 sonar.

For increasing the capabilities of ASW torpedo homing systems Navy is requesting $5 million. Another $18 million is listed to continue work on the Deep Submergence Program, involving "extended manned operation at air pressures corresponding to 600-ft. depths, personnel escape and rescue to depths of 2,000-ft. location, identification and recovery of small objects to depths of 20,000 ft."

For continued development of reactor propulsion plants, Navy requests $20 million—$6 million of the total to be applied toward a quieter submarine powerplant, $14.2 million for development of propulsion machinery for possible use on the Navy's next attack aircraft carrier. For the propulsion development on Navy's Sea Hawk ASW ship, $14 million is listed and $1 million is to be applied toward developing an integrated combat system for ASW ships.

- **Air Force**—The Air Force is requesting $8 million for work on an overland airborne radar and another $3 million for development of an airborne warning and control system (AWACS). These related projects are an effort to fill the need in a warning and control aircraft mission for "detecting and tracking airborne targets over land in the presence of severe ground clutter." Another $10 million is listed for developing reconnaissance strike capability—with multiple high-resolution sensors, such as side-looking radars.

A $1-million item in the Air Force budget is earmarked to wrap up the Stellar Inertial Guidance System (STINGS) project originally undertaken as part of the *Mobile Medium-Range Ballistic Missile (MMRBM)* development program, and $16 million is requested to continue the *X-15* rocket plane project for another year.

To fabricate and test several homing and tracking guidance heads for tactical missiles, $5 million is requested.

Continued study of "various technological and operational aspects" of an advanced ICBM carries a $5-million request. Another $6 million is requested for continuing effort on low-altitude supersonic vehicles *(LASV)*. Specifically, the *LASV* effort is to consist of "studies, tests and investigations designed to explore the feasibility of components which could provide the technical basis for the design of a chemical-powered supersonic, low-altitude vehicle."

- **Sub for Mauler**—Because of the "disappointing" progress in the *Mauler* anti-aircraft missile system for Army field use, $31.1 million is being requested to procure *"Chaparral,"* a modified *Sidewinder* missile mounted on vehicles, and to arm ground troops in forward areas with 20-mm guns. No line item for funding *Mauler* development appears in the FY 1966 budget.

In the engineering development category, Army is asking for $10 million for "further analysis of the forward-area air-defense problem," seeking a longer-range solution in the absence of an adequate *Mauler*.

TOW and *Shillelagh* antitank missiles adapted for such use are being considered as weapons for a new completely integrated, armed "helicopter-like" system as a replacement for the jury-rigged HU-1B in the Army's Aerial Fire Support program. FY 1966 funding should complete the *TOW* heavy antitank missile program.

In engineering development, Navy is listing $4 million for an ASW ship command and control system, more development money for the MK-48 torpedo, and $4 million for an ASW rocket-boosted ballistic-flight missile, designed to be compatible with the *ASROC* launcher and fire control system.

- **SRAM and Nike-X**—One of the most significant Air Force listings in engineering development is the short-range attack missile (*SRAM*), for which $37 million is requested in FY 1966, in addition to $5 million of reprogramed FY 1965 funds. The Air Force requests $9 million for target payloads to support the *Nike-X* development program. The target packages are launched by *Atlas* boosters from Vandenberg AFB over the Air Force Western Test Range. The Defense Secretary observed tersely that "no additional funds are being requested for *MMRBM* . . . since the Congress did not see fit to support the project." ■

MAN-RATED SPACECRAFT

...AND WHAT DOUGLAS IS DOING ABOUT THEM

Exploration of the universe by spacecraft capable of safely transporting men takes vast down-to-earth preparation. To accomplish this, Douglas has built what may well be the most advanced company-owned space complex in the world, the Douglas Space Systems Center. Here, in 11 buildings containing the most modern equipment—including a space simulation chamber 39 feet in diameter capable of housing a complete manned spacecraft—work is going forward on huge space programs. In advanced development is the *Saturn* S-IVB, the 58 foot long Douglas stage which will power the three *Apollo* astronauts from earth orbit to moon orbit.

To further these and other programs, Douglas is seeking graduate engineers experienced in reliability, electronics, propulsion or structures. Please send your resume to Mr. G. K. Snodgrass, Douglas Missile and Space Systems Division, 2730 Ocean Park Blvd., Santa Monica, California.
An equal opportunity employer.

DOUGLAS

MISSILE & SPACE SYSTEMS GROUP

Technical Countdown

ELECTRONICS

90-Gigacycle Radio Link Tested

An experimental millimeter-wave communications system is transmitting across Long Island Sound at a frequency of 90 gigacycles. The 1.2-mile radio link was established by the General Telephone and Electronics Labs to evaluate the potential of a compact, low-power millimeter-wave system using several solid-state components developed by the firm. The system has operated reliably since January, 1964, through all weather conditions. Both voice and coded data are being transmitted.

SNAP 19 Generators Delivered

The first pair of prototype nuclear generators for the *Nimbus* weather satellite have been delivered to NASA by Martin Co. The initial units contain no radioisotope fuel and will be heated electrically in the systems qualifications tests. Later units will contain plutonium-238 and are designed to deliver 30 watts of dc current to the *Nimbus B* satellite. The 30-lb. thermal converters are designed for a lifetime of five years. Spontaneous decay of the isotope generates heat within the tightly sealed devices, which is then converted directly to electricity by an assembly of thermocouples.

Raytheon to Produce Integrated Circuits

Raytheon will become a second source for certain molecular integrated circuits under an agreement with Westinghouse Molecular Electronics Div. The initial line involved is the Westinghouse 200 series of diode transistor logic (DTL) integrated circuits. The agreement is the result of DOD and military requirements for multiple sources of integrated circuits used in major military electronic systems. The compact is also expected to aid standardization and increase both the use and acceptance of integrated circuits.

Room Temperature CW Ruby Laser Developed

Continuous operation of a ruby laser at room temperature has been achieved by scientists at Hughes Aircraft Co.'s research labs. Although initial operation is at relatively low output levels, the technique shows promise of producing significant amounts of power—on the order of watts at visible frequencies. The laser consists of an ordinary ruby rod, 2 mm in diameter and 2.54 cm long, pumped to threshold by a single mercury lamp operating at 1,000 watts in a specially designed elliptical cavity. Water cooling is used. In a related experiment, Hughes experts have completely suppressed all but one mode from a small pulsed-ruby laser. The simple mode selection techniques are compatible with the CW configuration and should pave the way for solid-state lasers.

Adjustable-Spectrum Lamp Developed

Control of the spectrum of a 5-kw mercury-xenon lamp constructed for Jet Propulsion Laboratory has been achieved by controlling the temperature of a capillary tube attached to the main bulb. This determines the partial pressure of the mercury in the arc. Energy can be transferred from the infrared to the ultraviolet portion of the spectrum. Control of bulb temperature also allows an operator to compensate for the degradation of source and optics that occurs during extensive solar simulation tests.

ADVANCED MATERIALS

Silanes Double Strength of Glass/Plastics

Silane coupling agents can double the flexural strengths of glass-reinforced thermoplastic resin systems, say two scientists from Union Carbide Corp.'s Silicones Div. In a paper delivered this week before the 21st Annual Technical Conference of the Society of Plastics Engineers, S. Sterman and J. G. Marsden claim the strength-doubling effect of silane coupling agents on glass fibers is retained under both high humidity and temperatures. The complete mechanism is not fully understood, but it appears that chemical reactivity of silane functional groups with the resin is likely. Hydrogen bonding, polarity and Van der Waals forces may play a part in some systems.

Micro-thin Films Produced by Union Carbide

A family of microscopically thin plastic film named "Parylene" is in commercial production at Union Carbide Corp.'s Plastics Div. In processing, the monomer—in the form of a heated vapor—is allowed to contact any cool object. The vapor condenses and polymerizes into a tough, transparent plastic film. Continuous films thinner than one hundred thousandths of an inch can be produced. The simplest member of the family, Parylene N, is poly-para-xylylene. The film is now being used by a UCC division as the dielectric in a new series of Kemet-brand capacitors. The thin film makes possible capacitors only a fifth the size of conventional devices.

Solar Simulation Growing at JPL

A new solar simulator being installed at Jet Propulsion Laboratory is expected to have a 6-8 ft. beam and be capable of simulating solar intensity at Venus (270 watts per sq. ft.). Solar spectrum will be approximated by use of a mix of xenon and mercury-xenon compact arc lamps. Aim is for ±5% uniformity in the beam vertically and horizontally, with a divergence of 2° or less. Possibility of a giant simulator using a 12-ton, 23-ft. dia. mirror is currently being investigated, with consultations with manufacturers under way.

SPACE MEDICINE

Biomedical Function Simulation Pressed

A 10-lb. box that simulates the electrical signals of an astronaut's heart beat, blood pressure, oral temperature and respiration rate is being used to check out biomedical telemetry in test runs of the *Gemini* capsule. It is now being used by scientists at NASA's Manned Specacraft Center. MSC is contracting for a dummy to simulate the communications capabilities of the human astronaut for evaluation of oral communications. The head and shoulders dummy will have microphones for ears and a tape recorder operating in the human voice range, and will wear a pressure suit helmet sealed at the base to prevent acoustical leaks. Industry has been asked for proposals.

Ranger IX May Shoot Surveyor Site

Such a decision could defer launch until after March 17; Ranger VIII confirms findings of predecessor, but debate over lunar surface continues

by Willard E. Wilks

SPACE AGENCY officials are considering using the *Ranger IX* spacecraft to photograph potential *Surveyor* spacecraft landing areas.

A final decision will probably be made in the next two weeks. If such a site is selected, the launch will not take place until the latter days of the launch window which opens on March 17.

If the flight is attempted early in the launch window, it is scheduled to be launched at the Sea of Tranquility, the same lunar area which *Ranger VIII* photographed successfully on Feb. 20.

That spacecraft, launched on Feb. 17, transmitted more than 7,000 photographs back to the Goldstone, Calif., tracking station.

The photos verified what NASA had already found out from the *Ranger VII* photos—that no real knowledge of the composition of the lunar surface will be learned until the soft-landing *Surveyor* touches down on the Moon and sends back much-needed data on its strength.

Following preliminary analysis of the *Ranger VIII* photos, the program's scientific experimenters again disagreed in their interpretations of the make-up of the lunar surface.

Dr. Eugene Shoemaker, of the U.S. Coast & Geodetic Survey, said the new photos again indicated that the surface is smooth enough to safely achieve a U.S. lunar landing.

Another experimenter declared, however, that the surface appeared to be very similar to lava fields on Earth, and, if so, could prove to be a very treacherous landing site.

• **Mysterious switch**—The NASA decision to seriously consider photographing potential *Surveyor* landing sites with *Ranger IX* was made late last year.

At the same time, the primary mission for *Ranger VIII* was set to be the photographing of areas within 15° of the Moon's terminator in order to provide maximum information which was to be used to make a model of the Moon's surface.

About two weeks before the launch of *Ranger VIII*, Project *Apollo* officials requested the *Ranger* project leaders to switch the planned landing site from a point 13.5° above the Moon's terminator to a point within 5° of the terminator.

No suitable explanation was provided for the sudden switch in landing sites other than the fact that since *Ranger* is supposed to support the manned landing program, it was decided to photograph a potential landing area. There was no satisfactory explanation of why the decision was made only one and a half weeks before the launch when NASA had a seven-month period between the flights of *Rangers VII* and *VIII* in which to consider it.

Ranger VIII impacted on the Moon at a 2.59°N latitude and 24.77°E longitude. If *Ranger IX* is aimed at a potential site for *Surveyor*—scheduled to be launched toward the Moon early next year—it will probably be pointed toward a flat mare area near the Sea of Gassendi.

Apart from its attraction as a site for a manned landing, the Sea of Tranquility impact point also fulfilled a desire on the part of the experimenters to photograph a mare that was darker in color than the area photographed by *Ranger VII*.

"It was necessary to photograph a mare of darker color in order to decide the degree to which we can extrapolate the characteristics seen in the *Ranger VII* photographs," a spokesman said. "The new photos show that we can. Now we can proceed with more confidence in constructing the lunar model."

• **Landing, si**—Preliminary opinions drawn from the *Ranger VIII* photographs were divided as to whether the Moon offers safe landing sites.

On the positive side was the visual evidence that the second lunar sea photographed, Mare Tranquillitatis, showed terrain as smooth, if not smoother, than the section in Mare Cognitum photographed by *Ranger VII* last July 31.

Members of the photo evaluation team were not impressed—in fact, expressed relief—that the two maria looked much the same. They generally expressed the view that the lunar surface appears to present no landing problems as far as smoothness alone is concerned.

A NASA spokesman, emphasizing that the *Ranger VIII* pictures were in a region of potential *Apollo* landing sites, said both *Ranger* missions had revealed areas smooth enough for landing. He added that it now remains to be determined whether the lunar surface has adequate bearing strength.

Preliminary examination of the new photographs yielded no immediate new evidence regarding a lunar dust layer. Investigators continued to express the view that the surface may be either dust or a layer of small fragments ranging from micrometeoroid to rock size—or perhaps a mixture of both.

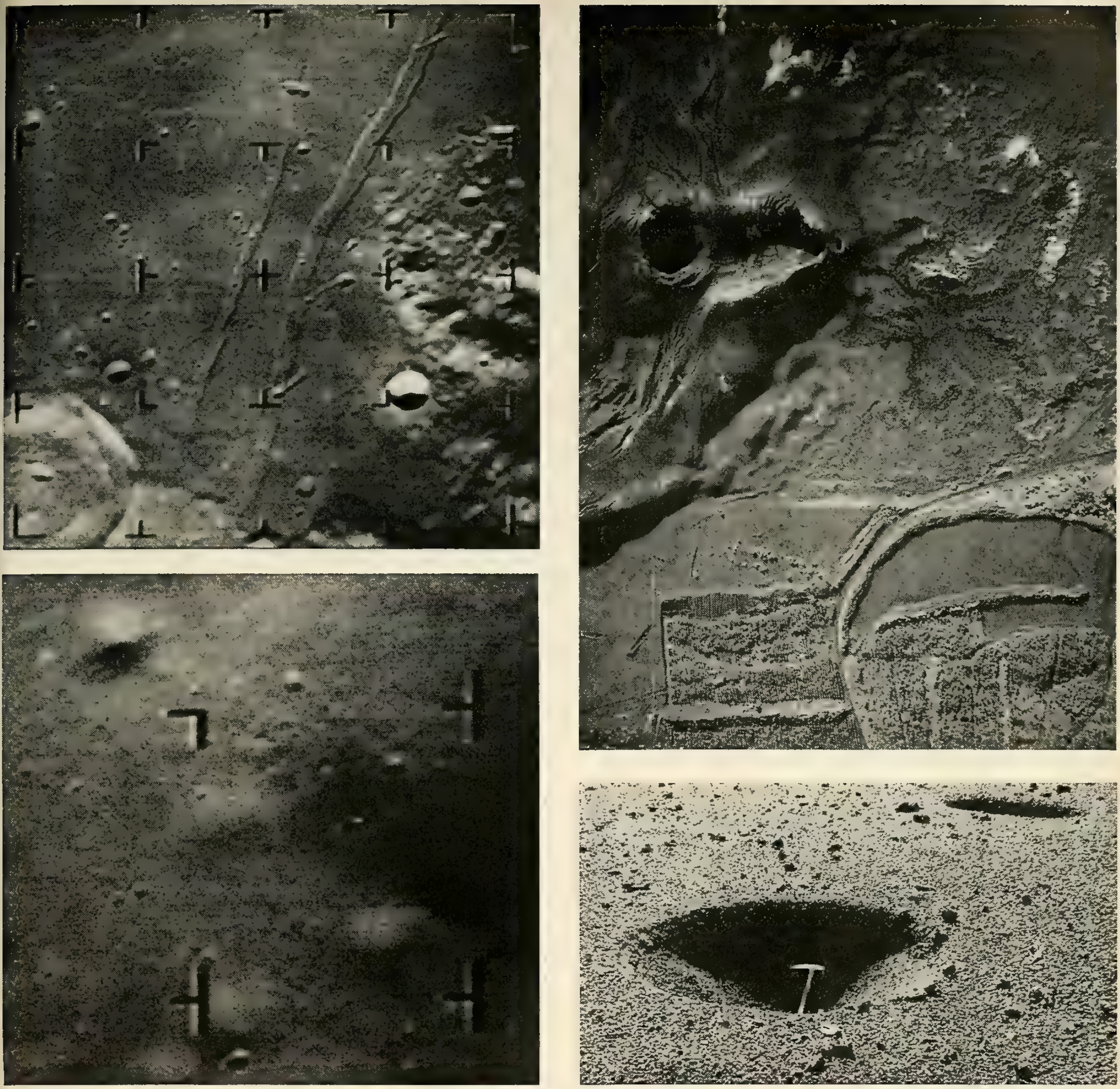
• **Landing, no?**—On the negative side was a theory advanced by Dr. Gerard Kuiper of the University of Arizona, chief evaluator of the photos. He said the maria may contain potential subsidence areas, and therefore could prove to be very treacherous landing sites despite their smooth, solid appearance.

Kuiper supported his hypothesis with photos of what he called drainage craters in a Hawaiian lava flow area (see photos), remarking that a member of a team investigating the site had been endangered when such a crater suddenly opened under his feet.

On the whole, the *Ranger VIII* mission was rated an excellent follow-up to the successful *Ranger* flight last year. The latest *Ranger* photographed a wider area than *Ranger VII*, revealing significant new features. As one of its prime objectives, it obtained pictures of lighter areas of the Moon.

The latest photos also were taken closer to the terminator in order to show the surface in better relief for photogrammetric study.

• **Better than VII**—Commenting on the spectacular success, which resulted in more than 7,000 photographs—nearly twice the number obtained earlier—Dr. William H. Pickering, Jet Propulsion Laboratory director, noted that the Russians so far have obtained



TOP LEFT: Television picture taken by Ranger VIII's Camera B four minutes before impact, at altitude of 270 miles, shows area of 58 mi. east to west, 43 mi. north-south. Shore line of Sea of Tranquility shows Sabine in northwest corner and two parallel rills, similar to terrestrial graben, in center. Elongated craters probably are due to Theophilus, 250 mi. to the southeast. BOTTOM LEFT: Enlarged detail from final Camera B photo 4.65 secs. before impact, at 5.1-mi. altitude, shows small rocks on slope of larger crater in southeast corner. TOP RIGHT: Subsidence craters in Laimana Crater area of Hawaii show how non-impact craters are formed in volcanic areas when surface material "drains" into hole underneath. Dr. G. P. Kuiper believes process could explain some lunar features. BOTTOM RIGHT: Portion of Laimana area. (Hawaii photos from Dr. Kuiper.)

only one poor-quality picture of the Moon's far side.

JPL personnel made no secret of the fact that the most immediately gratifying result of the flight was, as one spokesman put it, "showing that the first time wasn't an accident."

Ranger VIII impacted only 15 mi. from its aiming point at 2.59 deg. North latitude, 24.77 deg. East longitude, about 140 mi. from the *Ranger VI* impact point, after its 248,766-mi. journey. The spacecraft went into the lunar surface at an angle of about 42 deg. to the vertical, rapidly scanning more territory than did *Ranger VII*.

The entry angle enabled scanning of lunar highland areas, which is expected to yield better results from stereoscopic examination. Closeup photos of a rough highland area were made possible by a decision not to perform a terminal maneuver as *Ranger VIII* neared the end of its flight. A terminal maneuver would have eliminated the possibility of obtaining highland photos.

H. M. Schurmeier, *Ranger* project manager at JPL, said high resolution in the terminal photos was given up when the decision was made against a terminal maneuver. Denied this maneuver, experimenters had to accept more spacecraft motion near the surface and less "nesting" of photographs. But the result was wider coverage by the cameras.

Raymond L. Heacock, JPL member of the photo-evaluation team, estimated the final photograph could have had twice the resolution of that taken by

Ranger VII had the terminal maneuver been made. But as a result, he said, "we have a lot more to work with."

Smallest craters visible in the last *Ranger VIII* photo were 1 to 2 yards across.

The highland-area photos were considered an unexpected bonus. Kuiper said these pictures, taken with different cameras from different angles, should prove invaluable in the collection of more information about lunar elevations and processes operating on the Moon.

- **Gratifying sameness**—Kuiper joined the other four members of the photo evaluation team in expressing great satisfaction that the maria photographed by both *Rangers* presented the same general appearance. This he called one of the main results of the *Ranger VIII* pictures. He noted that a big question posed following the *Ranger VII* mission was whether the structure of other maria would be different from that of Mare Cognitum.

"The answer is 'no,'" he said. "They are very similar. If you didn't know the pictures were taken with *Ranger VIII,* you would think they were taken with *Ranger VII.*" He said an important impression made on the scientific team is that all lunar maria are "pretty much the same."

Another member of the photo evaluation group, Dr. Eugene Shoemaker, of the U.S. Geological Survey at Flagstaff, Ariz., said similarities between the two maria were striking—and this was "encouraging" for the *Apollo* project.

The effect of the new pictures was to give a green light to the investigators, who had been awaiting the latest *Ranger* results as a check on those obtained last July.

"We attempted to pick an area (for *Ranger VIII*) where there were some differences expected, and in fact got the same result," Shoemaker said. "Now we can begin to extrapolate to other areas of the Moon."

One reason it had been expected that the new mare might show different surface characteristics was because it is darker in color than Mare Cognitum. It has a bluish appearance, whereas Mare Cognitum is yellowish.

Kuiper believes Mare Tranquillitatis is newer; he theorizes that it was covered with lava more recently.

Compared with the *Ranger VII* results, the first of the new pictures released did not reveal as rapid an increase in number of small craters as the cameras neared the lunar surface. This apparently was because *Ranger VII* photographed part of an outlying ray of the crater Copernicus, where a greater density of small secondary impact craters could be expected.

- **Tricky footing**—All of the lunar scientists agreed, however, that mere surface smoothness is no indication that a safe landing could be achieved. They emphasized that *Surveyor* missions are a necessity for direct tests of bearing strength.

Dr. Harold Urey of the University of California at La Jolla, one of the photo evaluators, said the theory that the Moon may have a layer of dust running very thick in places still cannot be ruled out. But he said he did not believe this should prove a problem because dust should compress in a vacuum and present a firm landing surface.

Kuiper bases his hypothesis that the solid-looking maria may be hazardous landing sites on the theory that the lunar seas are lava flows overlaid by small fragmented material, similar to such flows on Earth. The lava-flow theory is supported by the fact that the maria appear to vary in color and the colored areas have sharply defined edges. This should not be the case where there are deep layers of dust, he said.

Kuiper sees great similarity between rounded depressed areas on the Moon and certain features of lava flows on Earth, such as in the volcanic Laimana Crater area in Hawaii. He displayed photos of the Hawaiian field, some showing craters formed when surface material falls into holes or cracks into hollow pockets underneath.

"Walking over such an area, a man can suddenly find the surface rubble caving in under his feet and draining into a hollow underneath," he said. "This is somewhat similar to the crevasse hazard encountered on glaciers. A man would have to feel his way along very carefully."

Kuiper points to rounded dimples, craterlets and troughs on the Moon as features that occur in volcanic areas. At the same time, he agrees with the general view that most of the lunar craters are impact features.

Some of the rounded crater features that drew great interest in the *Ranger VII* photos could be explained by the Kuiper theory.

If the maria are lava flows, they could be even more dangerous than such areas on Earth, Kuiper says, since in the lunar environment melted rock would tend to become frothy and form more holes and tunnels. Such material, with a density of one to two-tenths that of water, might have a load-bearing strength of a few tons per square foot, but would contain areas that would subside under weight, according to Kuiper.

- **Rare rocks**—Noting several rock-like objects in one of the first *Ranger VIII* photos to be released, Kuiper says larger rocks probably are very rare on the surface. He believes the surface may be so "fragile" that the larger objects impacting on the Moon disappear beneath the surface, leaving only smaller rocks above.

NASA officials have expressed some concern over the possibility that rocks could pose a hazard for *Apollo's* Lunar Excursion Module (LEM).

Kuiper, who provided the photo evaluation team with pictures of the Hawaiian lava flow, said this hypothesis is supported by studies he has made with very porous materials. Despite these views, however, he is not pessimistic about finding safe landing areas.

Shoemaker supported the idea that the lunar surface material may be composed of loose fragments representing material from craters and from infall of micrometeoroids. There could be a layer of such fragments over nearly the entire lunar surface, he said.

The analysts noted that the depth of some of the dimples seen in the photographs—estimated at 20-60 ft.—might be an indication of the maximum depth of the surface layer.

Urey called attention to the peculiar curved character of some crater walls, saying this might indicate hard material in the center.

- **Rills studied**—One of the features considered most significant and valuable for study, the evaluation team reported, is a pair of parallel rills, or troughs, photographed as *Ranger* neared the end of its plunge.

The rills were seen as not merely single, depressed areas, but as features containing a great deal of structure detail. Stereoscopic examination of pictures taken at different angles is expected to shed new light on the structure of the maria floor, its hardness and mechanical properties. The rills appear to be strips of land between two fault plains, according to Kuiper.

The rock-like formations in one photo drew considerable notice because they have proved to be rare in pictures returned from the Moon so far. One of them appears to cast a shadow.

Shoemaker said the objects probably are fairly recent features that have not eroded away. He said that a count of craters in the *Ranger* photos shows a discrepancy in the number of small craters compared with theoretical predictions, and that he believed this was due to erosion.

Recent studies of the cratering process have shown that small projectiles can produce surprisingly large craters. Some researchers believe this could explain the discrepancy.

Urey said there was evidence that some rather large masses, running to 10 million tons, had been thrown out of the crater Tycho. He said it was possible that impacts had dislodged some good-sized chunks of the Moon, and that these had travelled to the Earth. ■

Better Cratering Extrapolation Seen

Ames facility yields larger depressions, allows more accurate simulation of Moon's surface than previously obtainable

A STUDY into cratering phenomena being undertaken by NASA's Ames Research Center may shed new interpretive light on the *Ranger VII* and *VIII* photographs as well as on the cratering processes that have occurred on Earth and other planets.

The study employs a new vertical gun facility that is expected to go far toward alleviating a major difficulty usually associated with laboratory cratering research—extrapolation of small-scale results to investigation of large-scale events in nature.

Ames formerly was equipped with only horizontal guns, which precluded firing of projectiles into unbonded materials. Research thus was restricted to very shallow craters only a few centimeters in diameter.

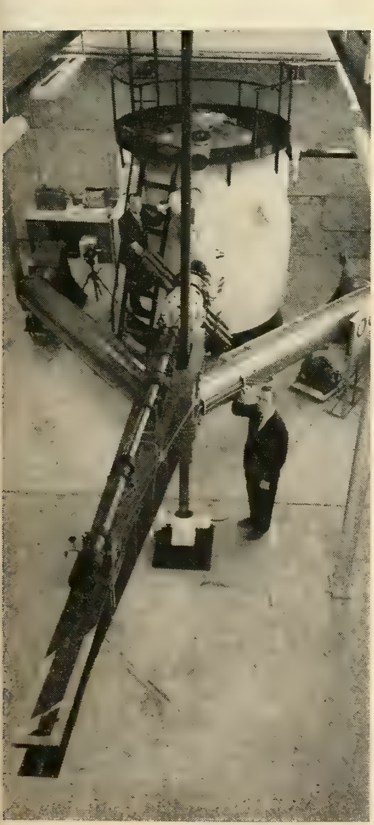
The new facility not only enables production of craters up to 3 ft. across but also permits simulation of lunar gravity as craters are formed.

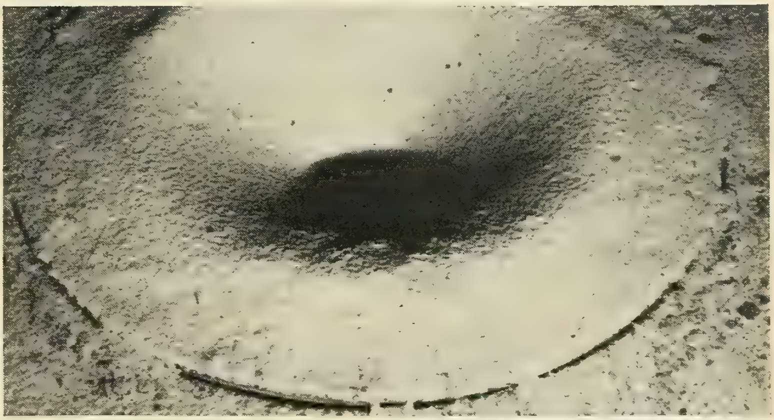
Craters the facility can produce are larger than the smallest seen in the *Ranger VII* photographs and therefore well above the minimum resolution.

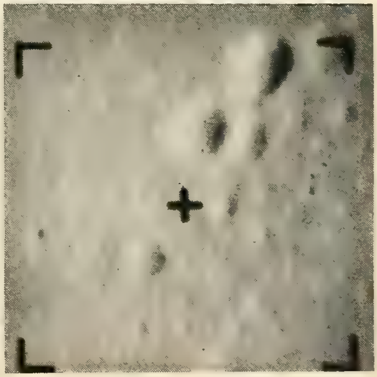
Problems associated with horizontal facilities are avoided: Loose, unbonded target material such as rock flour, sand or gravel may be used without spilling from the target box; with the target in a normal position, larger craters can be produced without tilt of the box causing slump after crater formation; disposition of the ejecta around the crater and the trajectory of the ejecta is easier to study than if gravitational acceleration is at an angle.

"We have taken a look at the scaling problems and are convinced that there are two prime variables we must understand and control to extrapolate to large secondary lunar impacts—target strength and gravity," Donald E. Gault, chief of the Planetology Branch, Space Sciences Division, told MISSILES AND ROCKETS.

- **Lunar gravity**—The new gun facility enables reduction of the gravita-







LEFT: Ames Research Center's Donald Gault, top, and Dr. William Quaide with vertical light gas gun being used in lunar surface studies. ABOVE: Crater formed by gun in unbonded sand at 1 km/sec. Impact was at 30-degree angle; crater diameter, 41 centimeters. RIGHT: Exclusive Ranger VII photo shows craters on Moon's surface a few meters in diameter. Those made in vertical light gas gun facility are similar in some respects.

tional field by permitting the target to drop vertically at a chosen rate so that lunar gravitational force acting at impact is simulated.

As part of its efforts, Ames also is conducting a field examination of larger craters produced by non-explosive warhead impacts at White Sands Missile Range, N.M.

The Ames study, outgrowth of a program started five years ago, is expected to enable better interpretation of the *Ranger* photos as to the strength and type of lunar surface material, and perhaps the depth.

Gault believes the work also will prove necessary for meaningful examination and interpretation of samples of materials that eventually will be returned from the lunar surface. It will study the melting that occurs on impact and any chemical fractionalization of materials.

"Many unusual things can happen when you shock-load materials," he reports. "To be able to understand and interpret what we find on the lunar surface, we will have to understand all of these effects clearly."

Associated with Gault in the study are Dr. William Quaide, assistant branch chief, Verne Oberbeck, and Henry Moore, of the U.S. Geological Survey.

Gault emphasizes the new study is much broader in scope than earlier investigations that were concerned mainly with how big a body it takes to form a crater of given dimensions.

• **New Earth interest**—In recent years, interest has increased in impact craters the Earth has sustained during its history, and geophysical diagnostic techniques have identified Earth features not previously recognized as impact formations. It has become apparent that the Earth has been battered as much as the Moon, but since the Earth features have been largely obliterated by erosion, investigators have turned more to the Moon, for information to help interpret what occurred on the Earth.

Since most of the craters seen in the *Ranger VII* photographs appear to be secondary in origin, the Ames investigation is concentrating mainly on secondary impact features, although the new facility is capable of shooting projectiles at speeds matching those associated with some of the Moon's primary craters.

The secondary craters are produced when surface material is fragmented by major impacts and thrown into ballistic trajectories, resulting in secondary, low-speed impacts.

• **Refining Ranger photos**—Ames investigators, equipped for their study with the 4,316 *Ranger VII* pictures and able to produce prints of much higher quality than those publicly released, have expressed some surprise that so many of the craters shown appear secondary in origin.

"The terrain photographed is generally very subdued, and it is surprising that we have seen no blocks of material scattered about, no positive relief," a spokesman said.

In one of the photographs, what at first was believed to be a meteor fragment protruding from a crater is now thought to be an optical effect produced by slumping in the crater walls.

With the new gun facility, Ames can achieve faithful simulation of the less than 2.4 km/sec. velocities associated with secondary craters. The facility has achieved velocities of nearly 11 km/sec., as compared with 12 km/sec. for primary lunar craters and the 20-30 km/sec. believed associated with larger lunar impact features.

"We have pretty well established that there are several prime factors we must look at in order to interpret the *Ranger* photos—the effect of impact velocities, the angle of impact and the strength of the target material," Gault said. "All of the work done in connection with the *Ranger* photos will involve low-speed impact, but even so, the range of low velocities involves changes in the cratering process.

"These factors control the cratering geometry and the ejecta blanket geometry. Exploring these could provide a background for a fair interpretation of the lunar surface, at least the upper 100 meters or so." Researchers doubt anything will emerge concerning lunar surface bearing strength, however.

• **Partial vacuum capability**—The facility also provides for operation in a partial vacuum, with pressures on the order of several hundred microns of mercury. Nature of the lunar atmosphere would not have a great effect on ejecta trajectories.

Various types of target materials will be investigated, including loose, partially bonded and solid rock. Materials believed typical of the lunar surface will be used.

Researchers are considering the possibility of developing some means to launch very-low-density projectiles against target material in order to investigate the theory that some larger crater features on the Moon and Mars may be the result of cometary impacts. It is believed the gases contained in a low-density comet head may have a different effect on impact than a solid body, producing a significantly different effect in the cratering process.

Projectile materials in use to date include cylinders of Pyrex glass and aluminum or iron. Effect of density ratio between projectile and target will be studied.

• **Firing the gun**—The projectiles are fired by light gas and powder guns used interchangeably in the vertical facility. The guns include two powder guns, 20 mm and .30 cal., and a .30 cal. light gas gun.

The guns can be fired obliquely to the target from 15 to 90 deg., in 15 deg. increments. The facility also can fire horizontally as well, so any angle from 0 to 90 deg. may be obtained.

For the lunar and planetary cratering research, the target remains horizontal, while the gun is tilted. Since most material ejected from an impact crater is thrown out at an angle of 30-60 deg., most secondary impacts are at an angle, and this is the area of concentration in the Ames program.

The gun facility's impact chamber is 8 ft. in diameter and 10 ft. high. Guns are mounted on an A-frame that straddles the chamber. In the vertical position, muzzle of the gun is about 10 ft. from the target material, which is as much as 18 in. deep.

Lunar gravity is simulated by dropping the 4-ft.-dia. target material box. The box never moves more than 8 fps and travels up to 12 in. Travel occurs in about .25 sec., ample time to fire the gun and form a crater under low g. The arrangement can approach zero g.

Ames' very preliminary results in the laboratory and from the White Sands investigations tend to confirm the idea that the lunar surface is littered with low-strength material. The White Sands craters provide a larger scale against which to compare the lab results.

The researchers report they have been somewhat surprised at the size crater a small projectile can produce.

Preliminary work to date has confirmed the idea that very low-angle impacts in unbonded materials always produce rounded, symmetrical craters.

The Ames project was undertaken as a separate research effort, not in direct support of the *Apollo* program. ■

New Scout Pact for LTV

NASA IS negotiating with Ling-Temco-Vought, Inc., Dallas, for an incentive contract to provide complete system management for the *Scout* launch vehicle.

The contract, expected to be worth about $8 million, will continue support services and materials LTV has been providing under several different contracts awarded at various times during the *Scout* development program. These include systems engineering, logistic support, operational support, test program support, payload coordination, pre-flight planning, data reduction and analysis, standardization and configuration control, reliability and quality assurance, vehicle modification, checkout and delivery.

'Moon Glow' Will Aid in Mapping

Bendix unit using lunar model with simulated lighting to calibrate TV cameras for use in making contour map of Moon

ANN ARBOR, MICH.—Techniques for using the Moon's peculiar reflectance in mapping the lunar surface from remote sensors are being developed here at the Bendix Systems Div., Bendix Corp.

Studies are under way to learn how the lunar landscape might appear to an image-forming device such as a TV camera and display system. The objective is to use the Moon's unique back-scattering lunar photometric function in determining the existence and nature of slopes and other surface features.

Bendix researchers have perfected lunar models that accurately simulate this reflective characteristic. The program is one of several supporting the Bendix decision to make extraterrestrial surface exploration a major interest of the firm.

A simulated lunar surface material—dubbed Photomat—has been used to fabricate lunar protuberance and depression models. Then problem areas were set up including navigation and control by remote means, creating a contour map and charting potential obstacles.

Bendix scientists under M. E. Amdursky, senior staff engineer, are studying resolution, gray levels, luminance levels and angular orientation of illumination and sensing.

The Bendix simulated lunar surface has been shown to have a photometric function in close agreement with theoretical lunar data developed by Hapke.

- **Canned curves**—The ability to measure the slope of a lunar terrain feature is based on the existence of a unique scattering curve for each position of the illuminating source—Sun or Earth.

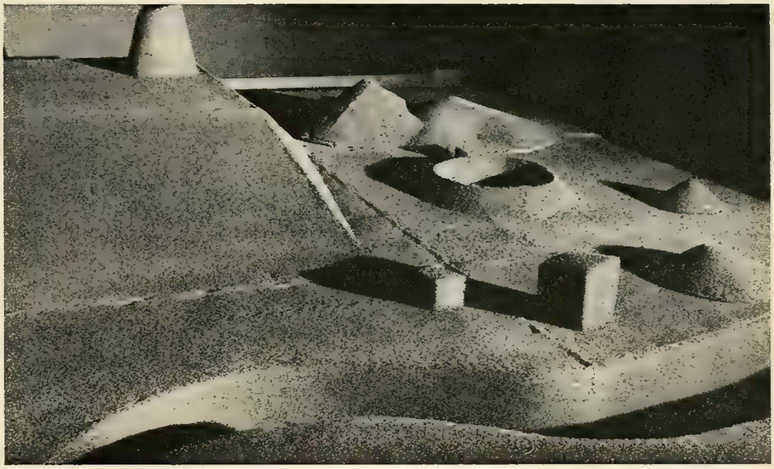
Once a portion of the absolute luminance curve is determined—by two or three points—it is possible to pick out which incidence angle curve is the best to fit to the data.

This fit, says Amdursky, is a direct measure of the apparent source angle or the source angle with respect to the normal surface.

The photometric method for determining the orientation of a specific surface from a remote location requires a calibrated photometric sensor whose pointing angles are known and a luminance reference scale.

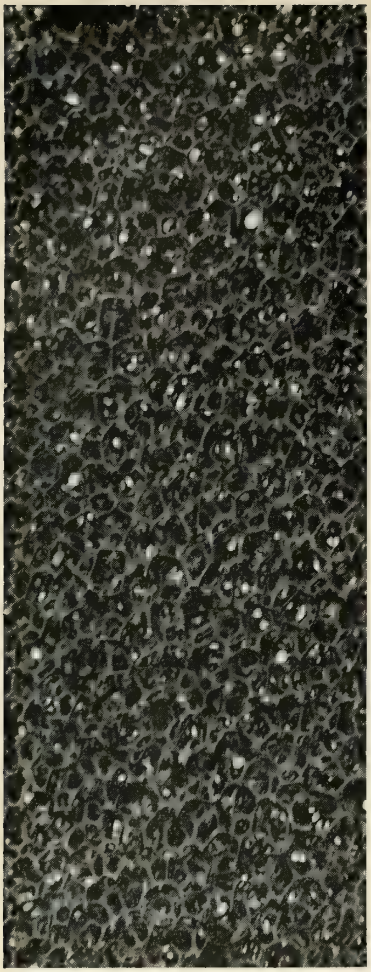
A properly calibrated vidicon TV system would suffice, says Amdursky, if all the transfer characteristics were detemined and the laboratory experiments set up.

- **Limitations**—There are limitations to the method—the photometric function is derived from data taken with large resolution, averaging more than 1,000 ft. of terrain. Also, the slope measured is really the projection of the slope in the line-of-sight direction. This



THE BENDIX Photomat material is used to simulate representative lunar protuberances and depressions. Model truly exhibits photometric characteristics closely simulating the back-scattering of the actual lunar surface.

A SMALL MODEL made of slag is pictured stereoscopically. Actual roughness of the terrain can be seen by using stereo viewer. The alien reflectance of lunar surface effectively conceals terrain features.



CLOSE-UP of the Bendix Photomat lunar surface simulation material.

component may not give an accurate picture of the overall slope, since luminance variations could be the result of different albedo levels. The accuracy of the method depends on the accuracy of measuring the true source angle, absolute luminance and relative camera angles.

To determine this inherent accuracy, a photographic camera was used as a photometric instrument, and the results were compared with the actual known slopes on the models.

Amdursky says the photometric function obtained for source incidence angles of 40°, 50°, 60° and 80° agreed very closely with the data from the photometer.

The photometric method was also demonstrated at Bendix using a conventional vidicon TV system as an intermediate link between the test surface and camera. The results indicated errors of approximately ± 10%, but these can be reduced through improving the calibration and by accurately establishing the operational characteristics for the specific TV cameras and displays being used.

Amdursky says the photogrammetric technique used on Earth may be applied to lunar mapping tasks. This involves a pair of photographs of the same area taken from two different viewing positions.

- **TV techniques**—The feasibility of using a slow-scan TV system as the sensor for photogrammetry was investigated and the method is feasible if TV imagery is at least of 200-line resolution and four gray levels.

The constraints placed on any lunar mission by weight, size, bandwidth and power consumption limitations require using frame rates considerably slower than conventional television, says Amdursky.

The exact frame scanning and transmittal rate of any specific system will depend on many factors for a given mission. Amdursky says the rates under consideration for *Surveyor* landing reconnaissance missions vary between one frame/sec. and 0.1 frame/sec.

Bendix researchers determined the effects of these slow rates on TV parameters such as resolution gray levels, linearity and dynamic range. A typical slow-scan system with selectable frame and line scan rates was obtained and evaluated by photographing the display monitor under a series of conditions.

The results indicate that the parameters considered are substantially affected by the frame rate, and meaningful data can be obtained for a given mission only by an evaluation of the specific system to be used.

- **Stereo assist**—Amdursky also found stereo viewing extremely helpful. The pits and depressions likely to be found at ground level observation are all but invisible using non-stereo techniques—but the same view on a stereo basis shows them clearly.

If provisions for stereo techniques can be accommodated at all on such missions, Amdursky feels they must be included.

Bendix researchers have not found color imagery much of an advantage. The experiments have included achieving a type of stereo response by using a color TV display where one image is blue and the other red.

One result of the Bendix work will be the ability to simulate the peculiar views lunar explorers must use and thus be able to train these men in depth perception and terrain relationships. ■

The Lunar Photometric Function

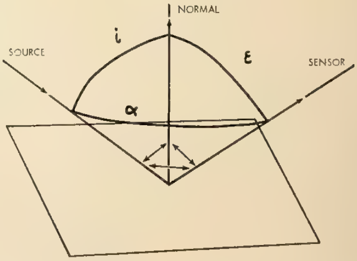
Experimental and analytical studies have shown that the lunar surface scatters and reflects its solar radiation in a unique manner. This is known as the lunar photometric function and the reflection is different from that of any other known photometric surface material.

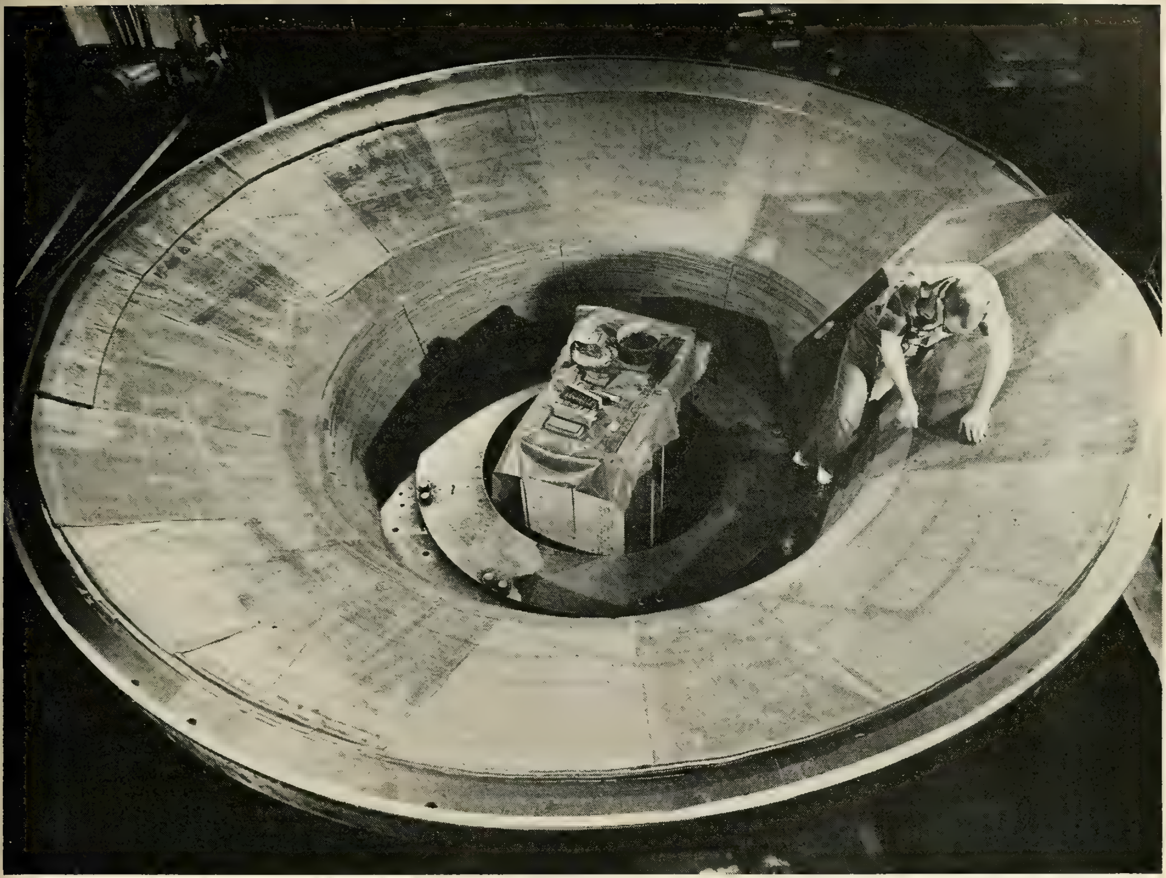
The reflectance of the lunar surface, says M. E. Amdursky, senior staff engineer at Bendix Systems Division, to incident visible radiation has been observed to be characterized by a peaked back-scatter in the direction of the source.

The shape of this characteristic depends almost entirely on the three directional angles in a spherical geometry. Thus, whereas diffuse surfaces obeying the Lambertian distribution law produce a directional reflectance or albedo depending only on the emmittance angle—the directional reflectance of the lunar surface is the product of the albedo and a function of the three angles—the lunar photometric function.

The relationship of these angles is shown above where i is the angle between the local vertical and the direction of source; e is the angle between the local vertical and the direction of the sensor and a is the source sensor (phase) angle—the angle between the line to the source and the line to the sensor.

It can be seen from the figure that $i + e = a$ is usually a spherical geometry, but when the source and sensor lie in the same plane it becomes a plane geometry. (Amdursky notes that the Sun, Moon and Earth or the analogy of source surface and sensor array for photography of the Moon's surface lie approximately in a plane.)





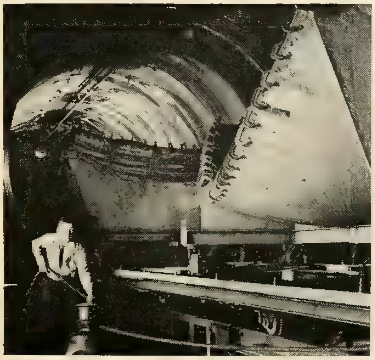
Insulation Liner for 260-in. Motor

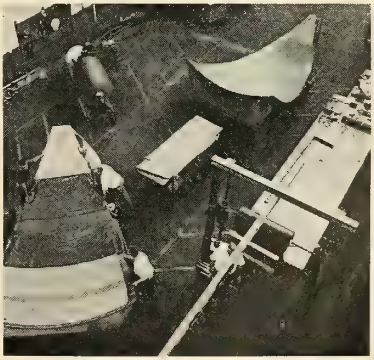
THE FINISHING TOUCHES are being applied to a 10,000-lb. rubber insulation liner at Goodyear's Aviation Products Div. prior to its mating to the nozzle for Aerojet-General's 260-in-dia. solid rocket motor.

The liner will be filled with about seven tons of plaster, shipped to TRW Electromechanical Div. in Cleveland where the plaster core will be replaced by the actual metal nozzle. The assembly will then be shipped to Aerojet's Dade plant in Florida for a static firing.

The final layer of green rubber is being laid-up in the top photo. Dome segment lay-up is shown at bottom left. The forward dome segments for the 260-in. motor were cured two at a time at Goodyear (below center). Dome segments are shown on the production line with the pre-production dummy of the first stage insulation for the *Minuteman* ICBM at the upper right (below right).

The *Minuteman* dummy was used to develop production and lay-up techniques for the 260-in. motor insulation process. The nozzle insulation was cured in a 15-ft.-dia. autoclave at Goodyear. The cure took 72 hours and a 600-lb., instrumented control slab was cured with the actual nozzle piece since a single mass of rubber this size had never been processed before.





LPC Big Solids R&D Leads to Interest In Volume-Limited Motor Production

by John F. Judge

REDLANDS, CALIF.—Fresh from its successes in the recent 156-in. solid motor competition, Lockheed Propulsion Co. is bearing down hard in propulsion for limited warfare and other high production areas.

The propulsion arm of Lockheed Aircraft Corp. set its sights on large solids shortly after Lockheed acquired the total assets of Grand Central Rocket Co. in 1961, but the research and development "seeding" programs instituted at that time are bearing fruit in that complex field loosely defined as limited or tactical warfare.

Robert F. Hurt, president of LPC, admitted that the firm has not been involved in high production, schedule-oriented programs. "But what people tend to forget," Hurt pointed out, "is that we are a division of Lockheed Aircraft and have experienced people in both LPC and the other corporate divisions thoroughly familiar with aerospace production techniques and problems."

LPC is under contract in a number of R&D areas and much of its detailed work is classified, but the Redlands complex has proven abilities in hybrid technology, throttleable and on/off-restart solids, and highly reliable motors for the *Apollo* program. The two-package award in the 156-in. large-solid program is a firm indication of the competence in this area.

Even though the R&D programs at LPC have been directed at quantum jumps in solids technology, attention is being given to applying today's propulsion knowledge to uprating currently operational weapons systems.

For example—LPC is studying recoilless rifles and is confident of extending both the range and substantially increasing the accuracy of these weapons through solid-propellant innovations. Another area is the use of maraging steels for lightweight guns. Still another possibility is the whole field of gun-launched rockets.

While segmented, solid rocket work is normally directed at launch applications, LPC finds the concept well suited to propelling rocket sleds.

Dr. Eugene Miller, director of advanced design, says that while advanced concepts are the key to new business, the present product areas cannot be ignored. There are uses for current propellants in areas such as positive ballast expulsion systems for submersibles.

- **Back at Potrero**—Propellant for three 156-in.-dia. solid motors will be produced with the aid of a new production facility at LPC's Potrero site, some 25 miles from the Redlands complex.

The new facility doubles the production capability of the firm to 120,000 lbs. per day—and is the second phase of a planned expansion to handle large solids production. Two of the 156-in. motor contracts—with 3-million and 1-million-lbs. thrust respectively—were recently won by LPC. The third motor is for a full-scale firing test of a hot gas valve for thrust vector control.

- **Cut handling time**—The Potrero facility consists of a propellant mixing station housing a 300-gal. vertical planetary mixer and support equipment capable of producing 60,000 lbs. of propellant per day.

A unique automated above-ground cast-and-cure station is included. The LPC plan minimizes the costly handling procedures for 100-ton segments. No large-capacity cranes are needed.

The key to the whole production layout is mobility—a programmed effort to minimize movement during the mixing, casting and curing of solid motors. The master plan includes mobile cast-and-cure stations in the 156-in. capacity size.

The ultimate aim is to use the extensive processing facilities at Redlands for research and development work and concentrate all production at the Potrero site. The firm has extensive test facilities at both Potrero and its Beaumont facility south of Los Angeles.

The current production installations are planned to accommodate 156-in. motor programs, but smaller motors can easily be produced on weapons systems schedules—at least initially—in the present complexes. LPC can start expanding these facilities for high production programs whenever necessary without affecting any specified schedule.

But the firm sees no future in expansion until actual programs are being negotiated. The propellant processing is well in hand and the production can be implemented quickly.

- **Hybrids**—J. E. Fitzgerald, director of Research and Engineering, feels the technology in hybrids has reached the point where funding of flight tests could be started. In this he is in complete agreement with the rest of industry.

The Lockheed method has covered both extremes in this technology. Substantial progress has been made in both the basic research areas and in the various hardware components of hybrid systems. LPC experts have developed a hybrid engine capable of throttling over a practical range with around 99% C* efficiency.

The approach was not Edisonian—investigations into the evaporation characteristics of oxidizer droplets in combustion chambers led to an understanding of the low combustion efficiency problems which plagued early hybrids.

This basic work coupled with intelligent experimental approaches has placed LPC in a position to claim with confidence an ability to fly a practical hybrid. There is more fundamental knowledge in hand in hybrids than with any other form of propulsion.

Fitzgerald says aft-end injection—the addition of oxidizer downstream in the combustion flow to maintain the correct oxidizer-to-fuel ratio—is a necessity in a hybrid designed for command, or random, throttling.

The turbulator is a requirement for all efficient hybrids and Fitzgerald describes the LPC innovation here as "a turbulator which takes up no room." If the hybrid is extremely large, the dwell time in the combustion area would probably be long enough to eliminate the need for such spoilers.

The Army is the prime customer and funds LPC's hybrid work to a current level of about $.75 million. Another $250,000 in Lockheed expenditures is involved and some $200,000 worth of mission studies has been performed. LPC has passed the 450 mark in hybrid test firings.

The last major point in LPC hybrid work is that the firm concentrates in room temperature systems and has avoided emphasizing all cryogenics and semi-cryogenic approaches.

- **Pintle progress**—Concern at LPC over controlled-thrust and engine restartability has resulted in the development of a "pintle" engine. This design has been fired and is essentially a throttleable, on/off, restartable liquid-augmented solid rocket motor. It is not a hybrid.

The motor is designed with a nozzle area slightly larger than that necessary to maintain pressure in the solid grain combustion area. A reactive liquid is admitted by pintle into the combustion chamber—which is surrounded by a fully-oxidized solid grain—and ignition is hypergolic.

The reactive liquid plus the solid grain provide enough pressure to push the engine operating characterstics to a level within the maintainability of the oversized nozzle. Throttling is accomplished by varying the flow of reactive liquid. Engine shutdown occurs when the liquid flow is ceased and restart is achieved by re-admitting the liquid.

The concept is neither size- nor duration-limited and has been tested through its capabilities with excellent response. The design is aimed at volume-limited applications in tactical rockets since it is a high-density concept.

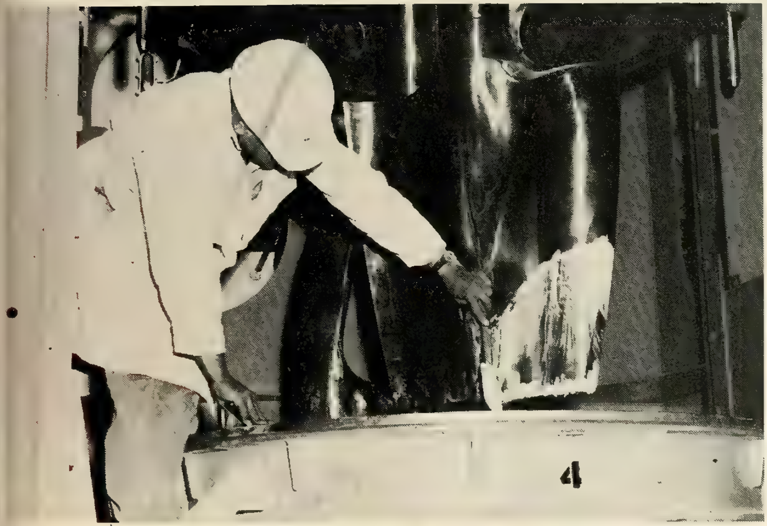
The pintle engine is an outgrowth of the hybrid research but is better termed a liquid augmented solid. The pintle mechanism admits the reactive liquid—forming the only moving part. The pintle concept is also being researched as a route to a variable nozzle —which leads to a fully throttleable, on/off solid rocket.

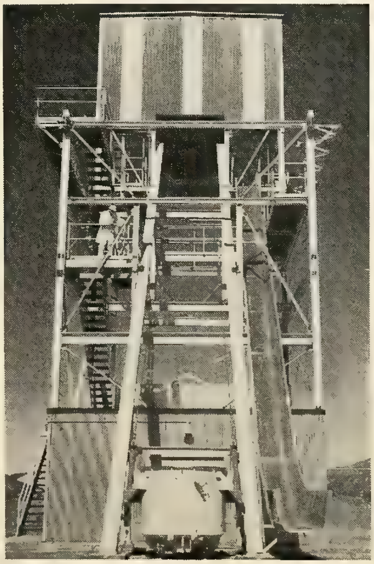
In addition to the two 156-in. packages now being negotiated, LPC is involved in the development of a new family of controlled-energy solid rockets based on its wafer concept. These pulse motors contain up to 40 propellant wafers, each with a thrust rating exceeding 1,000 lbs.

The *Mauler's* propulsion system and a solid rocket motor for a new air-to-air missile under development at Hughes Aircraft are other current projects. LPC is under contract to North American Aviation for the *Apollo* launch escape motor, which has been test-flown three times to date. There is also a small pitch motor designed to guide the spacecraft into an arcing path in case the escape motor has to be used.

Solid rocket technology is being used to develop an emergency ballast expulsion system for nuclear submarines under a Navy contract. ■

LOCKHEED
PROPULSION COMPANY





TOP LEFT: Oxidizer blender being prepared for oxidizer. TOP RIGHT: Pre-weighed and pre-mixed oxidizer blend is fed into the mixing process in this special tote bin at Lockheed Propulsion Co.'s Potrero site. Feed is automatic. ABOVE: Excess propellant is wiped from the blades of the new 300-gallon mixer. RIGHT: Above-ground cast-cure station showing the lift arrangement for hoisting the mix van to the loading station at the top of the 50-ft. structure. Loaded motor movement is minimized in this facility plan.

On-Line Computing Dominance Foreseen

Industry, ARPA experts agree that on-line systems will take over half the field in five years and 90% in another decade

by Rex Pay

Los Angeles—On-line computing will probably represent 50% of total computing activity in this country in five years, compared with a probable 1% today, claims Walter F. Bauer, President of Informatics Inc.

He further predicts that within 10 years this form of computing will represent 90% of all computer activity.

Bauer put forward these figures during an On-line Computing Systems Symposium at the University of California here. The arrival of over 700 attendees at the symposium, many from aerospace companies, gave support to the view that on-line computing is the main area of growth in computing today.

Agreement with Bauer's five-year prediction was expressed by Dr. Ivan E. Sutherland, Director for Information Processing Techniques at the Advanced Research Projects Agency of the Dept. of Defense. ARPA has a budget of $13.5 million for information processing this year; a large part of this is for on-line computing.

ARPA funds project MAC at MIT at a level of about $3 million per year. MAC (Machine Aids to Cognition, or Multi-Access Computer) currently involves an IBM 7090 serving 40 users as an aid in solving complex scientific problems. A General Electric 635 is soon to be installed there instead. ARPA also funds, at about the same level, a project at Systems Development Corp. SDC uses an AN/FSQ-32, which has been adapted to a time-sharing system, and its main interest is in the development of large software programs.

• **Nurtured by military**—The impetus for on-line computing came from large military systems such as SAGE and later developments, like the National Military Command System and the 473L system in the Air Force's Command Post at the Pentagon (M/R, Aug. 17, 1964, p. 26). These new systems enable commanders to keep track of and support strategic and tactical moves closer than ever before.

Typical of on-line systems is the closeness of interaction between the commander and the computer system. A commander in the National Military Command System wishing to have a list of airfields in five western states that have a POL (petroleum, oil, and lubrication) availability of 80% after an enemy attack would not have to convert his request to computerese and transform it into punched tape or punched card form. Instead, a staff officer would query the machine directly. He would press a button that would indicate he is interested in installations. The machine would give him a list to choose from and he would select "airfields." He would then tell the machine that he is interested in resources and chooses POL from a list the machine gives him. A similar procedure takes place with respect to geographic location. When he tells the machine that he is interested in an availability of 80% he is given a form on which to enter this percentage and the machine prints out the list.

Commenting on this example, Bauer said that the significant feature was that the format of the request was natural. The staff officer making the request is a military man who understands the commander's request and the reasons for it rather than the technical details of the machine. Bauer considers that computer-lead procedures of this sort, where the machine suggests types of questions that should be asked, is possibly the most important aspect of on-line use. It can be used for the insertion of data as well as for its retrieval.

The closeness of interaction between man and machine puts heavy emphasis on the problems of hardware and language involved in the communication. Also, because the man operates relatively slowly, systems of this type are only economical if they share their services between a large number of users. This raises problems of time-sharing and communications. All of these aspects of on-line systems received attention at the symposium.

• **Six examples**—In a keynote address to the symposium, Sutherland identified six kinds of on-line systems.

—Process control systems in manufacturing cut production costs and will have a big effect on domestic production capacity. They may ultimately cut the working force down to a residual 2% of the population.

—Inquiry systems permit people at different locations to find out what is going on. Most familiar is the airline reservation system, but many more types can be expected.

—Specialized on-line systems such as the 473L, which carry out special tasks for the military, are likely to come into use in manufacturing and design.

—On-line programming systems put the raw power of a computer at the immediate disposal of the user. Rand's Joss (M/R, June 15, 1964, p. 35) is an example of this type.

—On-line problem-solving systems will be developed that combine techniques of pattern recognition, process ontrol, and heuristic programming. 'hese automata are likely to begin to oncern ARPA in about five years. 'heir civilian use would be to tackle rocesses that are difficult to automate —shoe manufacture, removing and fillng knots in plywood, coal mining, for xample.

—On-line instrumentation will bring better understanding of the processes t work within the computers themelves. For example, a user will be easily ble to get a plot of the various running imes of his program and discover points vhere large cost savings can be realized.

Sutherland said that eventually we vill see communications between deigners and researchers through comuter systems. As an example he sugested the design of an aircraft. If one ngineer is designing the electrical viring and another is designing the gas anks, any change made by one must e communicated to the other as uickly as possible.

By merely providing up-to-date deign information to each user, an onne design system could be a great help. ut Sutherland thought the process ould be taken further: "We have yet o combine the functions of the design ystem and the inquiry system. The bility of many people in widely seprated locations to know exactly what s going on has proven practical already n the airline reservation system. It nust be included in our computer-asisted design systems."

He said, however, that there were ifficult human engineering problems n the communications link between the sers and the system.

- **Coping with the problems**—Turnng to specific problem areas within onne computing, Sutherland said that here had been remarkable strides in me-sharing techniques during the past ear. Ways to distribute memory storge, arrange priorities, and draw up chedules have been found. Now the conomic aspects of the different techiques have to be examined to find the nost suitable combination of methods.

Sutherland pin-pointed graphical echniques as a field wide open for exloration. "We don't have adequate tatements in program languages to andle graphical input and output," he laimed. "It is possible, I think, to do n-line sketching of programs, and a emonstration of this can be expected his year."

Highlighting other language probems in communicating with computers, utherland asked, "Why can't I write athematical equations which look like athematical equations and have the achine accept, compile and perform hem? Why can't I describe network roblems to the computer by means of he picture showing the network? Why can't I, in filter design, place poles and zeros on the complex plane? The answer in each case is: I can in principle but not in practice. The prospect of the next five years is exciting because there is so much that we know can be done, so much that we even know how to do, so much that we can put into use by just taking the time and trouble to do so."

One difficulty with on-line systems is that the computer programs may behave well, in spite of their great complexity, but the human operators may not. In computer jargon, you can "debug" the programs but not the people. Discussing this problem, A. M. Rosenberg, Scientific Data Systems, emphasized that "in the real world of human fallibility, it is essential to provide proper controls, idiot-proofing, escape hatches, etc." for the effective employment of on-line computer systems.

Rosenberg emphasized that once such steps have been taken, great value is to be gained in raising the dialogue between man and machine to the level of a discussion between several men by way of, and aided by, a computer. Typical applications were experimental games, group debugging or system testing, and consultation between a specialist at a computer and a user at a remote console. In some cases, man-machine-machine-man interactions will be profitable.

- **AN/FSQ-32 experience**—Because there are not many large, generalized time-sharing systems in existence, much of the full potential of group on-line interaction is yet to be explored, said Rosenberg. However, some experience has been gained with the time-shared AN/FSQ-32 computer at System Development Corporation. This has both local teletype stations and remote terminals using common-carrier facilities. Three types of inter-station communication are provided: Join, Dial, and Link.

- **Inter-station communications**—Experience has confirmed the value of Join, Dial and Link communications, and also the need to make allowances for unscheduled human behavior.

The Join function connects several stations to a common program, but only through the program itself. Primarily a service for experimental games, joining may be initiated through the game program by the originating station, to include other specified stations. The proper sequencing of the multiple user access to the common program is not very difficult. However, human errors call for special precautions. In particular, the originating station has to be prevented from joining a stranger against its will, to prevent an independent user's suddenly finding himself in an experimental game that he really has no desire to be a part of.

The Dial function permits station-to-station communication through an executive command. It was essential to the time-shared system in its formative stage since the hardware was, and to some extent still is, a tape-dependent system before a disc is installed. Station communication with the computer operators is quite heavy and the Dial command proves a significant asset.

It was the Link function that proved the most exciting. This enables two stations to act together with an object program, where the program has normal access to a single user. Any station may link to another station that is not currently linked. Both stations become in communication with the object program that is operating for the user. All inputs and outputs to and from the system are immediately seen at both stations, and a conversation mode is provided for unlimited direct communication between the linked stations.

In its simplest form, the Link function has been used for remote demonstrations, monitoring of various on-line operations, joint de-bugging, and for consultations and teaching services to new remote users.

However, not only was unexpected output interruption present, as it also was in the Dial function, but there was the added complication that the "intruder" was able to lay hands on the user's program. The linking station could issue a termination command and destroy the linkee's entire operation. Experience showed that this could be very frustrating.

Cases also occurred where sensitive information was being printed at one station and a stranger at another console could be using the Link function to obtain a copy of the restricted data. Although either of the linked stations could unlink, each could also prevent this action from taking place.

"It was no wonder then," said Rosenberg, "that during a local demonstration that was to be monitored remotely, a demonstrator panicked as soon as a link notice appeared on his teletype, appealing to be unlinked because his visitors were arriving at any moment."

One problem often occurred in use of the Link facility for teaching. It became necessary to find some way of preventing a pupil from interfering, accidentally or otherwise, with the consultant's input actions.

To cope with these problems, new variations of linking were developed. For simple monitoring of another station's operation, a secret link (Slink) was developed. No outputs from the monitoring station could appear at the monitored station's teletype. To cope with the problem of disarming interference from a linked station, a passive link (Plink) was developed. This prevents all program or system inputs from the monitored station from being carried out, although they can be seen from the monitoring station. Finally, a Stop Link command was developed to prohibit any station from having its privacy invaded by linking. All of these new functions require administrative approval before being activated by the time-sharing Executive, so that they have to be forwarded to a computer operator.

• **Hardware problems**—Also covered during the Symposium were problems with hardware. Bauer stressed the importance of obtaining a general-purpose console for on-line systems, preferably costing less than $15,000.

It should have a cathode ray tube or equivalent display, allow some buffering of information, and have a flexible and adaptable keyboard structure and status information display.

Other hardware aspects calling for attention, said Bauer, are memory protect hardware, multi-computers, which allow the incremental addition of modular components, and improved input/output devices. People on the programming side, said Bauer, should be putting more pressure on the manufacturer to get the equipment that is needed.

Software techniques requiring attention, said Bauer, were automatic segmentation of programs, relocatable programs and automatic relocation, computer use and program modification languages, console utility programs, and scheduling algorithms. ■

---

space electronics

RCA High-Speed Film Processor To Aid ASW

by Michael Getler

MOORESTOWN, N.J.—New high-speed film development and printing techniques are being combined with optical data-processing and display systems in a project that appears to be very promising for airborne photography, radar, and sonar reconnaissance.

Engineers here at Radio Corporation of America's Missile and Surface Radar Division, using a new, extremely fast, and "dry" film-processing system developed by Eastman Kodak Co., have built a basic processor and display system that yields high-resolution positive prints in less than 30 seconds. Access time below 15 seconds is possible under certain conditions.

RCA has applied the basic process to a series of developmental hardware systems operating with different film sizes and film transport speeds.

A breadboard system, operating with 35-mm film, is being used in the laboratory here for experiments to further explore the capabilities of the process in working hardware systems and also refine mechanical design for specific mission requirements.

Apart from this laboratory effort, RCA is working under a multimillion-dollar Navy contract to produce a prototype in-flight display system operating with a 5-in.-wide film. This will be evaluated by the Navy as an on-board reconnaissance display for patrol aircraft, providing a near-real-time visual read-out of data collected from anti-submarine warfare (ASW) listening devices.

The Navy is intensely interested in airborne monitoring of various sonobuoy submarine detection systems. It is paying more and more attention to data-processing and display functions, especially since the development of new detection systems that yield very large amounts of data (M/R, Sept. 21, p. 46).

RCA scientists feel that use of optical data-processing techniques—in combination with high-resolution, high-packing-density films and dry development processes that produce positives in seconds for immediate viewing without the "darkroom mess," chemical slosh, and corrosion problems of liquid systems—will allow data analysts to take full advantage of the advances made in the detection aspects of the ASW problem.

In fact, they believe these techniques may be the only way to mate near-real-time on-board airborne analysis with high-data-producing sensor networks and reconnaissance cameras. The RCA inflight work for the Navy, unde way since 1963, is thought to have involved one of the only requirement to date within the military for suc rapid on-board data display.

• **Two-fold use for Navy**—RC engineers told M/R that the technique for the Navy system have been developed, and that the equipment is no being built and will be delivered in mid 1965. The prototype equipment will include two sets of four 5-in. displays RCA, however, hopeful of a productio follow-on award, reports that futur units might take the form of singl eight-data-channel consoles, and b smaller, lighter, and capable of bein installed in all VS, VP, and helicopte aircraft used in ASW operations.

In addition to the display, RCA i using the Kodak process further "u front," employing a 16-mm system i the signal-processing section of th reconnaissance system to provide data-storage capability for subsequen signal correlation and analysis work The complete RCA system in effec acts upon the raw audio data collecte by the sensors, converting the transmitted electronic signals to optical signals which intensity-modulate the film

RCA also reports that it has mad extensive use of fiber optics in the signal correlation section for actually performing mathematical functions associated with optical data processing, an in the display section for readout purposes.

Separately from the Navy effort, th firm has already proposed variations o the basic technique to the Air Force for use in photo reconnaissance missions and in association with side-looking radar. Much of the lab developmen has utilized CRT displays as the ligh source.

RCA is also expected to discus some similar applications with the Army

It says other possible uses includ near-real-time read-out of data arrivin at satellite ground stations, comman and control system display, and som off-line detailed data analysis.

• **Bimat is key**—Heart of the RC system—and key to its high-speed capability—is the Kodak Bimat process. Kodak says the technique is a form of th diffusion transfer process, using a special polyester-base Bimat film—type SO 111—which is pre-soaked in a chemica film-processing solution.

When this Bimat is brought into contact with exposed negative film for th proper time and at the proper temperature, the processing solution develop the negative on the exposed film an also, through diffusion of halide-bearin solvent to the Bimat film, develops positive image on the Bimat.

At the end of the processing time the two films are slightly "tacky," Ko dak explains, but can be dried quickly with hot air if necessary for handling or storage purposes. In any case, the film is not "wet" in anything like the conventional sense.

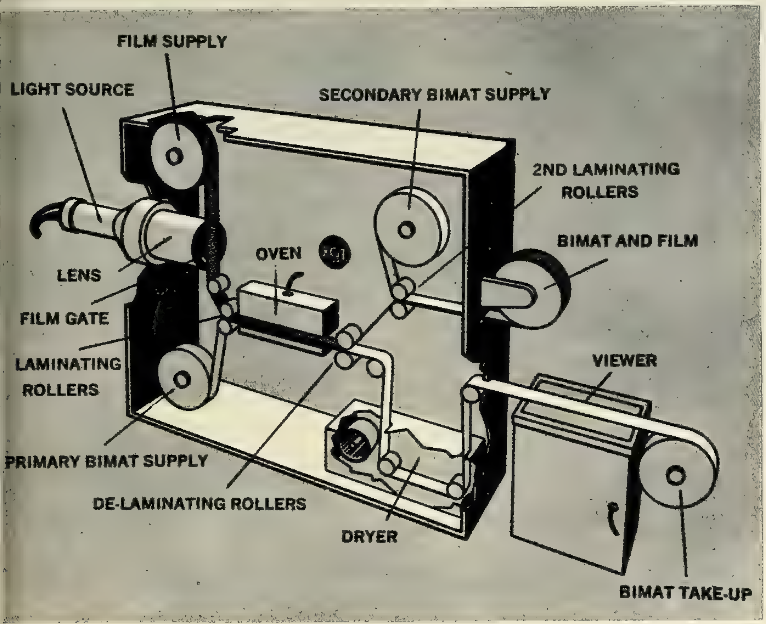
The Bimat film was developed by Kodak's Research Laboratories. It is being supplied in various sizes and quantities by the firm's subsidiary, the Recordax Corp., which RCA credits with important contributions to the application of the basic process to working hardware systems.

Kodak actually developed Bimat in the early 1960's; it first announced its availability in pre-soaked form last year. At that time, however, the process still took about 1½ minutes to produce a positive transparency and about 3 minutes to produce a processed negative, with the process taking place at room temperature.

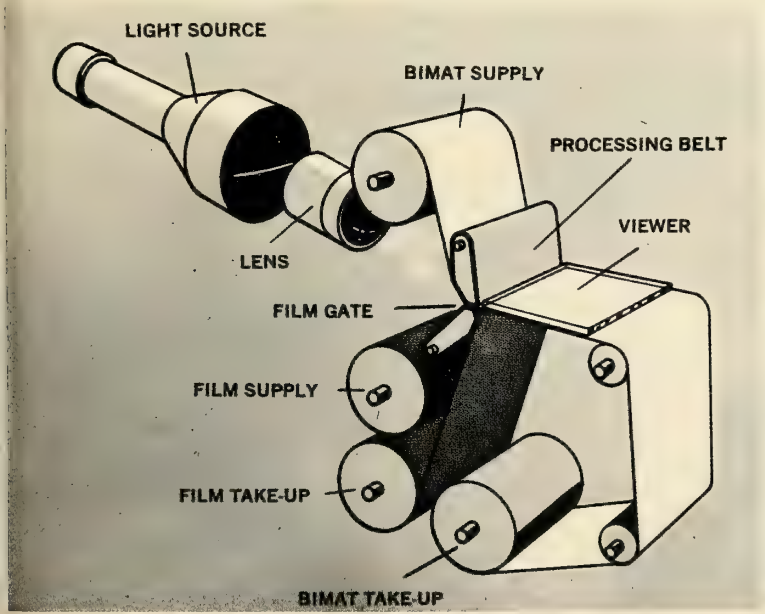
Since that time, working with very little publicity under an Air Force contract, Kodak has come up with a 30-sec. positive film which must be processed under higher temperatures. Basically, this film is what RCA is using; however, in the RCA project the positive is pulled after only 10 secs. of development for fast accessibility, sufficient for a high-resolution print, and the negative is then continued in process, if a fully processed negative is required.

Negative processing is completed by laminating the film to a second Bimat film for an additional development period. The total negative process takes 30 secs., according to RCA spokesmen. They point out that the additional 20 secs. of development are not critical for the positive.

Kodak is pushing still further into shorter development times for Bimat and increasing the ASA-equivalent speed of the film. A Recordax spokesman told M/R that in about six months the firm should have available an even faster process using a harder emulsion film. It is also reportedly working at improving the shelf life of the film, which must be refrigerated in storage, and at a development of a new process


FILM SUPPLY
LIGHT SOURCE
SECONDARY BIMAT SUPPLY
2ND LAMINATING ROLLERS
BIMAT AND FILM
OVEN
LENS
FILM GATE
LAMINATING ROLLERS
VIEWER
PRIMARY BIMAT SUPPLY
DE-LAMINATING ROLLERS
DRYER
BIMAT TAKE-UP

ABOVE: Laboratory model, operating with 35-mm film, is used to improve overall system operation and mechanical design. BELOW: Simplified schematic shows concept behind 5-in. film display system being developed for Navy. Positives have been developed using the system within 10 seconds.

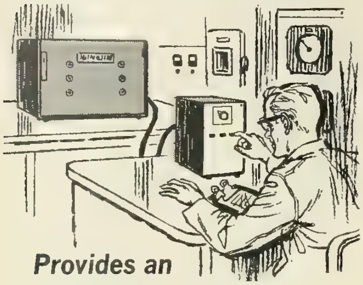

LIGHT SOURCE
BIMAT SUPPLY
PROCESSING BELT
VIEWER
LENS
FILM GATE
FILM SUPPLY
FILM TAKE-UP
BIMAT TAKE-UP

IN STEP WITH THE FUTURE . . .
ENCLOSURES FOR THE SPACE AGE!
Steel — Aluminum
- RFI Certified
- Heavy-duty
- Lightweight
- Stylized

What's your requirement?
Write for catalog-technical specs.
Amco ENGINEERING CO.
AMCO ENGINEERING CO.
7333 W. Ainslie St., Chicago, Illinois 60656

Circle No. 6 on Subscriber Service Card

MISSIMERS
PRECISION
SERIES
TEST CHAMBERS

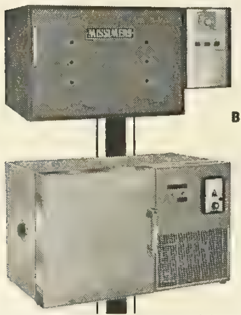


Provides an "Instrument" approach for extreme Accuracy in Temperature Testing

This unique design provides close temperature gradients of special variations in the test area, as well as providing for flexibility of use, performance, ease of maintenance and repair. Accessories such as component mounting boards, electrical access connectors, load cards, power supplies, scanners etc. can be added.

The BFT series is CO_2 or LN_2 cooled and can be bench or rack mounted. The units are available in four models; sizes of one-half and two cubic feet and temperature ranges of —100° F. to +600° F. and —300° F. to +600° F. The FT 1.5 series is mechanically refrigerated with a temperature range of —100° F. to +350° F.

WRITE FOR FREE BROCHURES



Reliable Test Equipment Since 1932

MISSIMERS
INCORPORATED
3741 SAN FERNANDO ROAD / GLENDALE, CALIF. 91204
Phone: (213) 245-8471

Circle No. 5 on Subscriber Service Card

which will yield a positive reflection print rather than a transparency.

Another interesting sidelight is that Kodak, should the film ever come into widespread use, reportedly is thinking of setting up a string of "soaking stations" around the country. Chemical soaking of the film for the high-temperature fast-development process is believed to be this critical to performance.

- **Two designs**—Translating the Bimat process into hardware, RCA has come up with two basic but similar systems, one represented by the laboratory model (Fig. 1) and the other by the in-flight display for the Navy (Fig. 2).

The lab model has been used to continuously record transient data from CRT's or other laboratory light sources. The negative film is first exposed in the gate and then laminated to the processing film between a pair of electrically driven laminating rollers. Then, says RCA, the laminate passes through an oven where processing is achieved in 10 secs. De-laminating rollers separate the films, which can be dried and negative-processed if required.

RCA engineers stress, however, that quick-look operational requirements would probably do away with the drying —and possibly with final negative processing—considerably reducing the hardware and the access time. RCA claims that removal of the dry cycle results in access times for the positive in the 35-mm lab model within 1-2 secs. after the 10-sec. development.

The lab model film-transport system is variable at rates between 0.3-in./min. to 1-in./sec. While these speeds are suitable for some applications, RCA engineers acknowledge that faster film transport will be required, with films of 70-mm widths and larger, to match camera outputs in a photo-reconnaissance application, for example.

A simplified version of the 5-in. in-flight display system being developed is shown in Fig 2. RCA has developed heated polyurethane transport belts which drive the film, control the critical laminating temperature, and maintain lamination for proper development and fix time.

The system uses a P-11 phosphor-type or equivalent light source, which permits film handling in a red-light environment, and operates at two film-transport rates—0.3-in./min. or 1-in./min., with an exposure-to-view access time of 30 secs. at the higher speed.

These areas—constant film transport speed, and maintenance of temperature and laminating pressures—are essential, engineers stress, for working near-real-time reconnaissance systems using the fast Bimat process.

Engineers also stress that the listed speeds at which the two units currently operate "are not limitations." RCA says paper studies of the 5-in. display system indicate that substantial increases beyond current speeds are possible with maintenance of the 10-sec. developmen process.

They also note, however, that efforts to apply the higher transpor speeds will be initiated by continuin advancements in Bimat processin speeds and film sensitivities. ∎

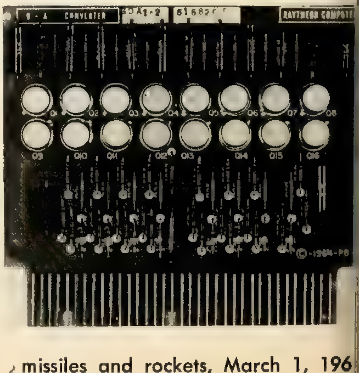
space electronics

New Product of the Week: Digital/Analog Converter

A digital-to-analog converter module that converts binary or binary-coded decimal inputs to proportional voltages is available from Raytheon Co.

The GDA1 module operates at frequencies up to 200 kc and accepts 8-bit binary or 8-4-2-1 BCD inputs. The device also can be used as two individual 4-bit converters. Analog voltage output ranges from 0 to — 6v maximum. For greater accuracy, the GRS1, a separate reference voltage supply module which generates a constant —5-volt reference, can be used.

Circle No. 151 on Subscriber Service Card



Calibrator

Electro-Nuclear Laboratories has developed the Model 450A Nanosource for calibration of laser detectors, photomultiplier time constants and photovoltaic and photoconductive detector time constants.

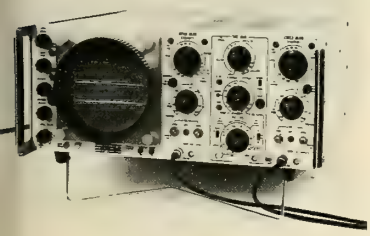
The device features rise and decay times of less than 2 nanosecs. The mercury arc source emits in the ultraviolet, visible and near-infrared regions pulses of permanently selected width (3 to 30-nanosec. range) at 60 pps. Peak output is 1 watt/steradian. The unit operates on 115v, 50 cps.

Circle No. 152 on Subscriber Service Card

Dual-Beam Oscilloscope

A dual-beam, 10-microvolt-sensitivity oscilloscope, featuring a high-resolution cathode ray tube, has been announced by Fairchild Scientific Instruments.

The Type 708A has a sweep range from 100 nanosecs./cm. to 1 min. full scale. The CRT has a 5-kv accelerating potential and is driven by transistorized amplifiers. Viewing area is 8 x 10 cm. Bandwidth is dc to 500 kc (down 3 db).



Circle No. 153 on Subscriber Service Card

Temperature Sensors

H. E. Sostman & Co. is marketing three new series of platinum resistance temperature sensors, each available in two grades of interchangeability.

Interchangeability Option A offers interchangeability of ± 0.5%. Interchangeability Option B offers interchangeability of 0.25°C and 0°C and 1.6°C at 500°C. Various configurations are available, the smallest having a stainless steel sheath diameter of 0.125 in.

Circle No. 154 on Subscriber Service Card

Phase Angle Voltmeter

A multi-mode phase angle voltmeter for use in field test and ground support systems has been announced by North Atlantic Industries, Inc.

The Model 245 features a wide range of options, including ac modes for measurement of in-phase, quadrature, total and fundamental voltages, as well as phase angle. A dc measurement mode option is also available.

The solid-state unit uses silicon transistors and meets MIL-T-21200 specifications. Used as a VTVM, it has a measurement capability of 10 cps to 100 kc. In the phase angle mode, it offers an operating range of 350 cps to 10 kc with null resolution greater than 1.0 microvolt. It has 13 selectable ranges from 300mv to 300v full scale. Both modes offer a ±5% bandwidth without adjustment.

Circle No. 155 on Subscriber Service Card

Silicon Amplifiers

Burr-Brown Research Corp. has available the Model 1643 and 1644 operational amplifiers. The all-silicon, chopper-stabilized units are especially suited for use in integrating, differentiating, sample and hold, and as low-level preamplifiers, the firm says.

The units have outputs of 50 and 100v, respectively. With 160-db gain and three-megacycle unity gain open loop bandwidth, the drifts are as low as ± 0.01 na and ± 1 μv per degree Centigrade. Operating range is — 40° to 85°C.

Circle No. 156 on Subscriber Service Card

Self-Contained Test Set

A self-contained test set that automatically produces a strip chart recording the deviation of a potentiometer from true linearity is available from Associated Research, Inc.

The Model 8582 includes all necessary regulated power supplies, synchronous motor drive, standard potentiometer, chart recorder and holding fixture. Controls are included for single-turn potentiometers having less than 360 degrees rotation and for 10-turn potentiometers having less than 3,600 degrees rotation.

The unit has a resistance range of 10-100/100-10,000/10,000-1,000,000 ohms and a recorder sensitivity of 1, 5 and 10%, full scale.

Circle No. 157 on Subscriber Service Card

Transistor Curve Tracer

Rameco Corp. has available the Model CTA-1 transistor curve tracer, developed to provide an inexpensive means of adding this capability to any general-purpose dc oscilloscope.

The unit features a peak voltage range up to 240v in 4 steps and automatically traces 5 steps per family in the common emitter configuration. Base currents of from 20 microamps to 1 milliamp are provided. The device tests both PNP and NPN transistors. A collector load selection provides 12 resistance values of from 10 to 100,000 ohms.

Circle No. 158 on Subscriber Service Card

VLF Function Generator

A VLF function generator, the Model SG-88, has been developed by Houston Instrument Corp. The device is capable of generating complex low frequency waveforms in any shape—mathematical or non-mathematical—that is single-valued and repetitive.

In the device, the oscillator circuit is replaced by a rotating transparent disc scanned by a narrow light beam. Silk-screened on each disc is an opaque pattern representing in polar-coordinates the waveform or function to be produced. Light penetrates the disc at the transparent areas and is deflected onto a photo-electric transistor by a spherical mirror.

Output frequency is variable from 0.005 to 50 cps. DC voltage level at the output terminals can be set to any value between ± 25v from ground level. The waveform (at 40 cps) and output voltage level can be monitored by a built-in oscilloscope with 1-in.-dia. CRT.

Circle No. 159 on Subscriber Service Card

High-Purity Metals

Precious metals in ultra-high-purity single and polycrystalline forms are being marketed by Advanced Materials Div. of Materials Research Corp.

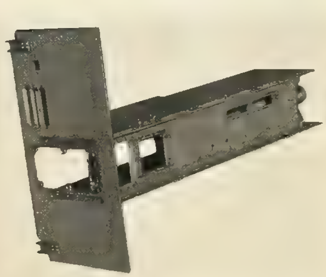
Iridium, palladium, platinum, rhenium, rhodium and ruthenium are prepared by electron beam zone refinement in vacuums of 10^{-6} torr or better. Gold and silver are prepared by vacuum melting and Bridgman control growing techniques.

Circle No. 160 on Subscriber Service Card

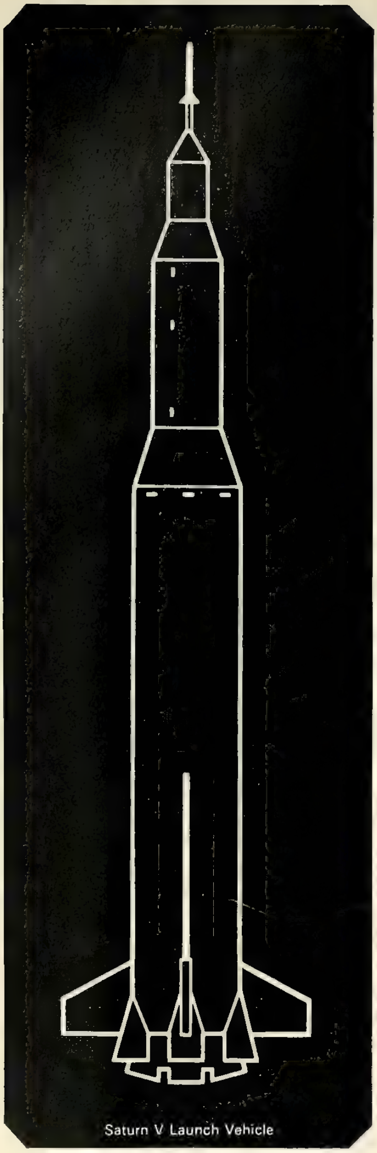
Energy Sink

R. O. Roberts Co., Inc., is marketing a thermal efficiency sink for airborne electronic equipment.

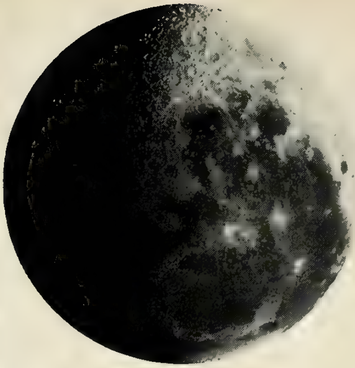
The unit is designed to have the equipment modules mounted directly to its surface. Thermal energy generated by the equipment is transferred by conduction to surfaces of the cold plate. Interface conduction losses are minimized by a 32-RMS surface with a flatness of 0.0001 in./in., the firm says. The all-aluminum device is pressure tight at 12 psig and weighs 3.4 lbs.

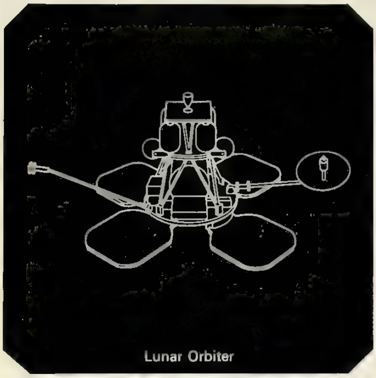


Circle No. 161 on Subscriber Service Card

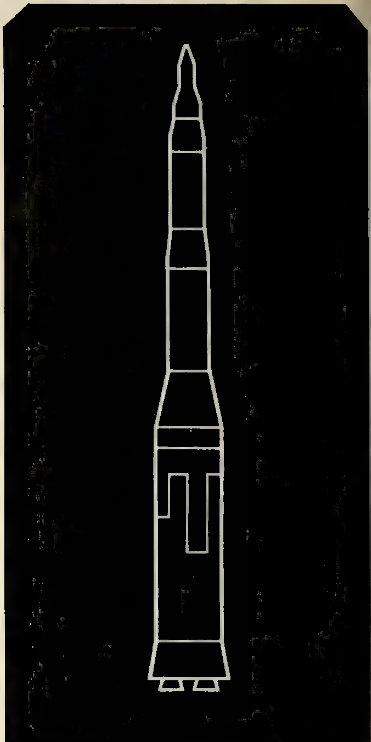


Saturn V Launch Vehicle



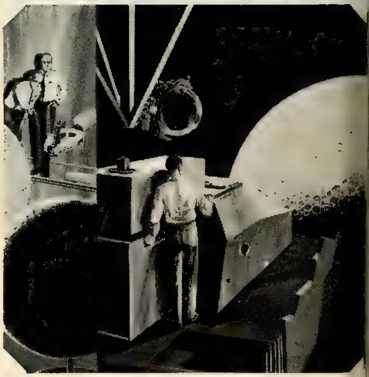


Lunar Orbiter



Minuteman ICBM

Space-Age Boeing Openings



Space Research

for Engineers and Scientists

The Boeing Company's Aero-Space Division, major contractor for the Saturn V launch vehicle, Minuteman ICBM and the lunar orbiter, has a number of challenging opportunities for graduate engineers and scientists. (See list in right-hand column.) Assignments, which vary with each Boeing facility, are at Cape Kennedy, Fla.; Huntsville, Ala.; New Orleans, La.; Seattle, Wash., and Vandenberg AFB, Calif.

Minimum requirements are a B.S. degree in an engineering or science discipline, plus applicable experience. Salaries are commensurate with your experience and education background. Travel and moving allowances are paid to newly hired personnel. Boeing is an equal opportunity employer.

Send your resume today to the employment manager at the installation(s) you prefer: Mr. L. S. Bonsteel, Boeing Atlantic Test Center, P. O. Box 1698 - MSX, Cocoa Beach, Fla.; Mr. John Hall, Boeing Launch Systems Branch, P. O. Box 1680 - MSX, Huntsville, Ala.; Mr. L. Wendell Hays, Boeing Launch Systems Branch, P. O. Box 29100 - MSX, New Orleans, La. 70129; Mr. John H. Taylor, Boeing Pacific Test Center, P. O. Box 1626 - MSX, Vandenberg AFB, Calif., or Mr. Lawrence W. Blakeley, The Boeing Company, P. O. Box 3822 - MSX, Seattle, Wash. 98124.

Systems Engineering • Flight Technology • Telemetry Systems and Design • Electronics Technology • Instrumentation • Propulsion and Mechanical Systems • Scientific Computer Programming • Logistics Engineering • Aerospace Program Planning • Metallurgy • Test Engineering • Electrical/Electronic Design • Materials & Processes • Human Engineering • Cryogenics • Weights Engineering • Guidance & Control • Reliability • Service Engineering • Mechanical Design • Structures Analysis & Design • Computer & Logic Circuit Development • Industrial Engineering • Electronic/Electromechanical Parts Evaluation • Computer Systems Analysts

BOEING

Divisions: Airplane • Turbine • Vertol • **AERO-SPACE** • Also, Boeing Scientific Research Laboratories

The Industry Week

New Activities

Technical Explorations Co. has been formed in Dana Point, Calif., to conduct research and development work in optics, radiation and plasma physics and in related areas of advanced technology. TEC presently has under development a superradiance source for use in solar simulators. . . . *H. I. Thompson Fiber Glass Co. stockholders have voted to change the corporate name of that Gardena, Calif., company to HITCO. The change is subject to final approval by the California Commissioner of Corporations. HITCO makes super-high-temperature reinforcing fibers and acoustical insulation.* . . . Columbia Technical Corp., Woodside, N.Y., has formed a Micro-electronic Div., which will enter the integrated circuit market. CTC has been conducting an R&D program in the field of cermet hybrid circuits for the past seven years. The new division is the second added to CTC in recent months. The other was formed through the acquisition of Industrial Mica Corp. of Englewood, N.J. . . . *International Resistance Co. of Philadelphia has formed a Microcircuits Div. to manufacture its line of microelectronic products. The microcircuits operation was formerly an R&D function.* . . . Solid State Instruments Corp., a Cambridge, Mass., subsidiary of Kollmorgen Corp., has changed its name to Inland Controls, Inc. . . .

Mergers and Acquisitions

Western Gear Corp., Lynwood, Calif., has acquired the Transmission Systems Div. of Kaman Aircraft Corp. of North Caldwell, N.J. The acquisition was for an undisclosed amount of cash and includes tools, machinery and business assets, all of which will be integrated into WGC's Precision Products Div. . . . *Kay Resistor, Gardena, Calif., and Angstrohm Precision, Inc., of North Hollywood have joined under common management. The companies plan to continue operations on their present sites and to continue independent marketing and manufacturing programs, but joint programs leading to new product lines are under active consideration.* . . . Geartronics Corp., North Billerica, Mass., designer and manufacturer of electromechanical devices, multiratio gear motors and custom-designed precision gears, has acquired Nashoba Engineering Corp. of West Concord, Mass. Nashoba makes a wide variety of machinery for the electronics and wire and cable industries. . . . *Itek Corp. of Lexington, Mass., and Chicago Aerial Industries, Inc., Barrington, Ill., have reached tentative agreement on a plan for combining the business of the companies. Terms provide for the acquisition by Itek of all net assets of Chicago Aerial Industries for $6,760,000 in cash and 28,000 shares of Itek common stock and the dissolution of CAI. CAI is engaged in the tactical reconnaissance field; Itek, in R&D and fabrication of reconaissance, optical, photographic, electro-optical and information-handling systems. The move, subject to CAI stockholder approval, is aimed at diversifying Itek's activities in the military market.*

International

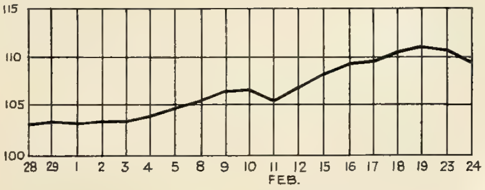
Alloy Surfaces Co., Wilmington, Del., and the French Office National d'Etudes et de Recherches Aerospatiales (O.N.E.R.A.) have signed a cross-licensing agreement which makes French metal-treating devices and processes available in the U.S. Seventeen U.S. and Canadian patents obtained from O.N.E.R.A. in the field of metallurgy are covered by the agreement. A separate provision provides for exchange of technical and scientific personnel between the two firms. . . . *TRW Space Technology Laboratories, Redondo Beach, Calif., and Hawker Siddeley Dynamics Ltd., Harfield, England, have signed an agreement for exchange of technical information on satellites and other spacecraft.* . . . Electronic Specialty Co., Los Angeles, has designed, built and installed an automatic telemetry tracking system in Sardinia, Italy, for the European Space Research Organization. It will be used to track sounding rockets for upper atmosphere research.

Missile/Space Facilities

Babcock Electronics Corp. has started construction of a 125,000-sq.-ft. facility for the firm's Aerospace Div. in Costa Mesa, Calif. Completion is expected in June, 1965. . . . *Metal Bellows Corp., Sharon, Mass., has expanded design engineering and fabrication facilities to build complex bellows hardware for critical performance systems. The added capability will permit the firm to bear complete responsibility for design and functional reliability of complicated instrument hardware, the company says.*

Missile/Space Stock Index

Release of Secretary McNamara's defense posture statement, coupled with the Viet Nam situation, focused continued attention on defense contractors. Space successes of *Ranger* and *Pegasus* also contributed to a general upsurge in missile/space prime manufacturers' stocks. Investors who bought stock in all 19 of the Missile/Space Index companies would have realized an almost 10% gain for the two months beginning Dec. 31.



STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

contracts and procurements

AWARDS

AIR FORCE

$25,185,000—**The Boeing Co.,** Seattle, to assemble, install and check out *Minuteman* ICBM's.

$6,300,600—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for research and development work on an unspecified space program.

$4,594,318—**General Motors Corp.,** AC Spark Plug Div., Flint, Mich., for work on the *Titan II* missile guidance system.

$1,500,000—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for research and development work on a satellite control network.

$306,000—**The Boeing Co.,** Seattle, for a 22-month study to develop advanced processes for applying protective coatings to large, complex metal parts for use in space vehicles.

Entron, Inc., Silver Spring, Md., for 59 power supply modules and 59 amplifier modules in the 30-300 mc range (amount not disclosed).

ARMY

$15,886,635—**Bulova Watch Co.,** Woodside, N.Y., for artillery fuses and safety-and-arming devices for air-to-ground rockets.

$8,079,000—**Koppers Company, Inc.,** Malan Construction Dept., Pittsburgh, for construction of the second of two test stands for ground firing the S-II second-stage of the *Saturn V/Apollo* at the Mississippi Test Operations of NASA.

$3,552,528—**General Dynamics Corp.,** Pomona, Calif., for work on *Mauler* weapons systems.

let us move with you!

Six Weeks Is Required To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, **if possible, the address label from your last issue . . .** include your postal zone or zip number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

NAVY

$3,643,182—**Honeywell, Inc.,** St. Petersburg, Fla., for manufacture of gyroscopes.

$1,414,000—**Clevite Corp.,** Cleveland, for research and development on guidance equipment for use with torpedoes.

$1,165,700—**General Electric Co.,** Pittsfield, Mass., to produce training equipment for the *Polaris* weapons control system.

$1,083,840—**Northrop Corp.,** Norwood, Mass., to make gyroscopes.

NASA

$10,940,000—**Douglas Aircraft Co.,** Santa Monica, Calif., to provide services on the *Delta* vehicle for another year.

$8,879,832—**Sperry Rand Corp.,** Univac Div., St. Paul, Minn., for 22 digital data-processing systems to be used in connection with Project *Apollo* space flight missions.

$1,397,000—**Dortech, Inc.,** Stamford, Conn., for manufacture of the *Saturn S-1C* stage transporters.

$200,000—**Space-General Corp.,** El Monte, Calif., for conceptual design of an instrumented capsule which could be hard-landed on the Moon to test sites for manned landings.

$199,800—**Northrop Corp.,** Nortronics Div., Norwood, Mass., for design, fabrication, assembly and test of general purpose electronics for testing precision gyros and inertial guidance equipment.

$174,000—**Belock Instrument Corp.,** College Point, N.Y., for design and development of solid-state celestial scanner.

$169,961—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., for development of passive temperature coatings for use on *Apollo* vehicle ablative thermal protection.

$100,000—**U.S. Atomic Energy Commission,** Oak Ridge, Tenn., for development and testing porous ionizer materials directed toward achievement of long-range goals.

$81,782—**TRW/Space Technology Laboratories,** Redondo Beach, Calif., contract add-on to perform studies of a unified lunar descent sensor, investigate modulated varactor power sources and experimentally evaluate the operation of the extended range altimeter.

$70,857—**Meteorology Research Inc.,** Altadena, Calif., for turbulence measurement system.

$27,270—**Allied Research Associates, Inc.,** Aracon Geophysics Co., Div., Concord, Mass., for investigation of thte feasibility of sea surface temperature measurements from satellites.

$25,500—**Wm. S. Watkins & Associates,** Willoughby, Ohio, for design of electrical power control communication and instrumentation systems for gravity research facility.

Lockheed Aircraft Corp., Lockheed-California Co., Burbank, Calif., supplemental contract for engineering design support for the Manned Spacecraft Center in Houston (amount not disclosed).

INDUSTRY

$1,500,000—**International Telephone and Telegraph Corp.,** Federal Laboratories, Nutley, N.J., from **Aircraft Armaments Corp.,** Cockeysville, Md., to develop sonar simulation techniques and equipment for the Navy.

$375,000—**Whittaker Corp.,** Power Sources Div., Denver, from **Lockheed Missiles and Space Co.,** Sunnyvale, Calif., for production of primary batteries for the *Polaris A-3* missile.

$190,000—**General Applied Science Laboratories, Inc.,** Westbury, N.Y., from **Aerojet-General Corp.,** Aetron Div., Covina, Calif., **NASA,** Cleveland, Ohio, and the **Naval Air Development Center,** U.S. Navy, Johnsville, Pa., for low frequency analysis systems.

$82.843—**Operations Research Inc.,** Silver Spring, Md., from **Bendix Corp.,** Systems Div., Ann Arbor, Mich., to assist in a comprehensive long-range arms control study.

Textron, Inc., Dalmo Victor Div., Belmont, Calif., from **North American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., to develop the high gain, deep space communications antenna system for *Apollo's* round-trip to the Moon (amount not disclosed).

EUROPEAN SPACE RESEARCH ORGANIZATION

$600,000—**Robinson Technical Products, Inc.,** Hig Vacuum Equipment Corp., Teterboro, N.J., for the construction of a space environmen chamber for installation at the European Spac Technology Centre (ESTEC), Delft, Netherlands.

DEPARTMENT OF DEFENSE

$500,000—**Tellurometer, Inc.,** Washington, D.C. for 213 Tellurometer electronic distance measuring instruments.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, Calif. 04035

RFP due date March 15, 1965 for developmen of a high radiance, high-powered radiation source RFP number A-9735 FG-14 will be sent on first-come, first-served basis.

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, Calif. 04035

RFP A-10180/TT-41 due date March 12, 196 for angular accelerometers with a range of 0.0 deg/sec 2 to 30 deg/sec 2-3 ea. Requests fo copy of RFP will be sent on a first-come, first-served basis.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama 35812
ATTN: PR-EX, C. H. Brown

MSFC will negotiate with North America Aviation, Autonetics Division, for a researc study of structural bending adaptive control techniques for large launch vehicles. For informatio only, RFP not available.

Directorate of R&D Procurement
Systems Engineering Group
Research and Technology Division
Wright-Patterson AFB, Ohio

Negotiations will be conducted with Hughe Microwave Tube Division of Hughes Aircraft Inc., for continuation of applied research o efficiency improvements in O-type traveling wav tubes. For information only, RFP not available.

George C. Marshall Space Flight Center
Huntsville, Alabama 35812

RFP DCN 1-5-60-00053-01 due date March 3 1965, for research for improvement in control c automated space vehicle stage checkout. Copie of RFP available on first-come, first-served basi U.S. Army Missile Command

Procurement and Production Directorate
Special Contracts Division
Non-systems Negotiation Branch
Redstone Arsenal, Alabama 35809

Selected source procurement with Brown Engineering Co. for weapons analysis and method-ology modification study. It is suggested that mall business firms or others interested in subcontracting opportunities in connection with this procurement make direct contact with the firm.

Commanding General
Army Missile Command
Redstone Arsenal, Alabama 35809

The Army Missile Command proposes to pro-ure from Bell Aerosystems Co. a program to lemonstrate the feasibility of using aluminum ladders for expulsion in the Lance missile. Firms interested in subcontracting opportunities hould direct inquiries to Bell Aerosystems Co., Niagara Falls, N.Y.

Fort Monmouth Procurement Division
Procurement and Production Directorate
J.S. Army Electronics Command
Fort Monmouth, N.J. 07703

Study and analysis of satellite communications cheduling techniques, RFP-AMC(S)-28-043-65-0699, due date for receipt of quotations approxi-nately March 30, 1965. Copies will be furnished the extent available on a first-come, first-erved basis.

Chief
Bureau of Ships
Vashington, D.C. 20360

Technical documentation services to prepare, dit and furnish change pages to the Mk 2 SINS nanuals; RFP to be issued to Autonetics Division f North American Aviation, Inc. It is suggested hat small business firms or others interested in ubcontracting opportunities in connection with he described procurement make direct contact vith North American. Security clearance required f all bidders or offerors.

Chief
Bureau of Ships
Vashington, D.C. 20360

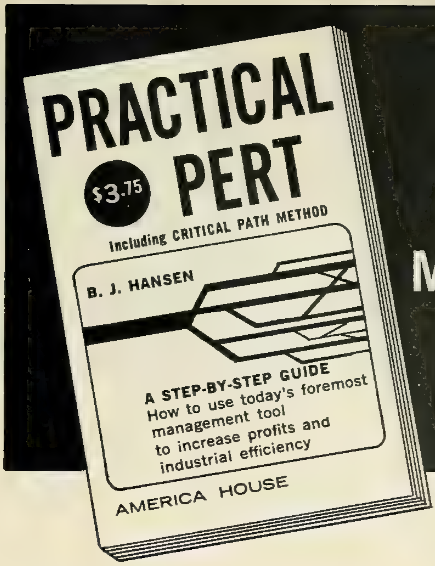
RFP will be issued to North American Avia-on, Inc., Autonetics Division, to conduct house ystem and associated test and maintenance pro-rams for the Mk 2 SINS systems. Small business rms or others interested in subcontracting op-ortunities should make direct contact with North merican. Security clearance required.

J.S. Naval Ordnance Laboratory
Vhite Oak
ilver Spring, Maryland

Research and development sources sought for study leading to the design of a propulsion sys-em for an underwater weapon system. Responses hould contain all information necessary to sub-tantiate their qualifications and should be sent the procurement office listed above marked to he Attn: SS-41, in accordance with the provisions nd by March 8, 1965.

Vational Aeronautics and Space Administration
lectronics Research Center
Cambridge, Mass.

Research and development sources sought to onduct a study of lunar, planetary and solar opography techniques. Interested sources should ubmit complete information indicating total umber of employees, professional qualifications f scientific and technical personnel, description of acilities available, an outline of previous projects uccessfully completed in this field. Respondents vill not be notified of results of evaluation of in-ormation submitted, but sources deemed qualified vill be considered when RFP's are issued.


PRACTICAL PERT
$3.75
Including CRITICAL PATH METHOD
B. J. HANSEN
A STEP-BY-STEP GUIDE
How to use today's foremost management tool to increase profits and industrial efficiency
AMERICA HOUSE

FOR ALL LEVELS OF MANAGEMENT

2nd Big Printing!

$3.75

by B. J. HANSEN

(member of the original Polaris-PERT Team)

You get the complete **PERT** system and, for the first time, a **PERT** technique showing you how to predict and monitor profit on a continuing bi-weekly cycle.

Chapter XII, "Profit **PERT** and Incentives," brings you the Martin Company case history showing how the Titan III **PERT**-profit system works: In the words of Secretary of Defense Robert McNamara, "(Titan III) is probably the best managed contract we have, and it is the best managed almost entirely because of the tremendous incentive given to that contractor in the form of potential profit increases to hold his costs down."

PRACTICAL PERT tells how and when to meet contract obligations, how to keep programs on schedule, how to win highest incentive fees. **PERT**, developed for the nation's defense programs, can be applied to management operations to monitor profit as well as cost, time and performance in the fields of construction, chemical processing, manufacturing . . . and wherever complex systems are involved.

PRACTICAL PERT contents

I INTRODUCTION TO PERT
II THE ABC'S OF PERT
III PERT & TIME
IV HOW PERT PLANS
V HOW PERT CONTROLS
VI BUILDING PERT
VII WHAT IS NETWORKING
VIII REFINING THE NETWORK
IX MEASURING MANAGEMENT RISK
X PERT & COST
XI PERT COSTS & COMPUTERS
XII PROFIT PERT & INCENTIVES
XIII PERT DATA DISPLAY

AMERICA HOUSE
Dept. A
1001 Vermont Avenue, N.W., Washington, D.C. 20005

Send Me ☐ Copies of Practical Pert $3.75
.25c Handling
$4.00

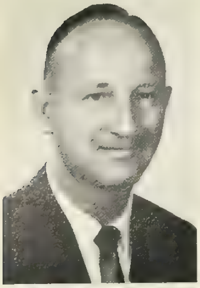
☐ Check Enclosed ☐ Bill Me

Name ________ Job/Title ________

Address ________ City ________ ☐ HOME? ☐ BUSINESS?

Zip Code ________ State ________ Co. Name ________

names in the news


MALONEY

HUMPHREY

SCHULTZ

SHAFRITZ

LYNN

Hughes Aircraft Co. has made the following promotions: **Dr. Allen E. Puckett,** former vice president and executive head of the aerospace group, became executive vice president. Succeeding Dr. Puckett as vice president of the aerospace group is **John H. Richardson,** former vice president and assistant group executive. **C. Harper Brubaker,** vice president and group executive for the company's ground systems group, has been promoted to the post of senior vice president.

Robert S. Maloney, Jr.: Appointed manager of system projects for the Radio Corp. of America Service Company's missile test project. He will direct the organization, which coordinates and controls the company's activities on a number of major programs concerned with new data acquisition and processing instrumentation on the Air Force Eastern Test Range.

Gordon S. Humphrey: Elected vice president and general manager of the Leach Corp.'s Controls Division. He joined Leach in 1962 after having spent the previous 18 years with Raytheon.

Paul G. Schultz: Promoted to vice president and general manager of Huyck Systems Company division of Huyck Corp. He has been with the company since 1963.

Arnold B. Shafritz: Elected vice president of Auerbach Corp. He has been a member of the board of directors for seven years, and is also director of the Information Sciences Division. He will retain both of these positions.

Computer Sciences Corp. has promoted the following executives to vice president: **Roy H. Lynn,** Lt. Gen. USAF (Ret.), will become vice president of the parent company; **Armig G. Kandoian** will head Communication Systems Inc. (formerly ITT Communication Systems, Inc.) as vice president and general manager; **Alvin E. Nashman** was named vice president and general manager of System Sciences Corp. (formerly ITT Intelcom); and **Richard M. Hultberg** will assume Nashman's former position as director of operations and vice president of the SSC.

Dr. Robert W. Bussard: Joined Electro-Optical Systems, Inc. as manager of advanced systems concepts and technologies. He will coordinate all power and propulsion activities and interests. He was responsible for basic reactor design and program planning in the Nuclear Propulsion Division of Los Alamos Scientific Laboratory and is nationally noted for his pioneering efforts in nuclear rocketry.

Donald C. Morrisey: joined Rocket Research Corp. as chief of rocket engine development. He is a specialist in liquid propellant control rockets and was formerly employed by the Marquardt Corp. and Hughes Aircraft Co.

Ivan E. Robinson: Elected president of DATA-tronix Corp., manufacturer of telemetry components and systems for use in such programs as *Saturn*, *Ranger* and *Mariner*. He was formerly division manager of the Robinson Division of Hewlett-Packard Co.

President Johnson recently presented the National Medal of Science at a White House ceremony. **Charles Stark Draper,** professor of aeronautics and astronautics; **Solomon Lefschetz,** mathematician; **Julian Swinger,** physicist; **Harold Clayton Urey,** astronomer; **Robert Burns Woodward,** biochemist; and six others were presented the award for recognition of creative achievement and leadership in mathematics, biology and the physical and engineering sciences.

Lawrence Levy: Rejoined Allied Research Associates, Inc. as president and chief executive officer. He will also be a director of the company. He founded Allied Research in 1951 and served for 10 years as president and chief executive officer. In 1961, he took a leave of absence to accept a Presidential appointment as principal civilian representative of Defense Secretary Robert S. McNamara in Europe, North Africa and the Middle East.

Fred R. Sullivan: Elected to the board of directors of Nopco Chemical Co. He is president and a director of Walter Kidde & Co., Inc., and also a director of Litton Industries, Inc.

Maj. Gen. George P. Sampson (U.S.A. Ret): Appointed as director of operations for the Communications Satellite Corp. He recently retired as Deputy Director of th Defense Communications System and wa with the Army for 23 years. He was als technical representative at the Geneva ne gotiations to establish the Washington Moscow hot line.

Thomas J. Murrin: Elected vice presi dent-manufacturing of Westinghouse Elec tric Corp. He joined the company in 195

Gerald J. McCaul: Appointed executiv vice president of CompuDyne Corp. an general manager of the Systems Div. H was formerly with Kollsman Instrumer Corp.

Emil R. Borgers: Appointed vice pres dent of Scientific Data Systems. He wa formerly director of programming. Als appointed as vice presidents were **Dan I McGurk** (marketing) and **Robert P. Adam** (development engineering).

Dr. Arthur H. Williams: Elected vic president of Operations Research Inc. an appointed director of the company's De fense Systems Analysis Div. He has bee with ORI since 1958.

Arthur J. Cussen: Appointed presider of Electro-Optical Industries, Inc. He wa formerly vice president of Infrared Indu tries, Inc.

William F. Masler, Jr.: Appointed vic president of Aero-Flow Dynamics, Inc. an president of the Aero-Corry Div. He wi be concerned with the design, developmer and production of electropneumaticall actuated butterfly valves and airborne fu filtration devices.

Myron G. Newberger: Elected to th Avnet, Inc. board of directors. He is pres dent of Avnet Corp. and vice presider of Avnet, Inc.

David S. Johnson and Dr. S. Fr Singer: Awarded the Department of Con merce's highest award—a gold medal f exceptional service—for playing a majo role in the development of the Weath Bureau's National Operational Meteorolo ical Satellite System.

Justin J. Guidi: Appointed manager *Apollo* and *Polaris* programs for Raythe Co.'s Space and Information Systems Di

—when and where

MARCH

Unmanned Spacecraft Meeting, sponsored by the AIAA, International Hotel, Los Angeles, March 1-4.

Twenty-first Annual Technical Conference of the Society of Plastics Engineers, Statler-Hilton Hotel, Boston, March 1-5.

Design of Space Systems for Power and Temperature Control Course, University of California, Los Angeles, March 1-12.

pace Education Institute, sponsored by the University of Maryland and AIAA, Baltimore Campus, Baltimore, March 1-May 3.

Advanced Planning Briefings for Industry, sponsored by the Department of Defense and the National Security Industrial Assn., Ambassador Hotel, Los Angeles, March 3-4.

Conference on "Project 60", sponsored by the American Society for Quality Control, Hotel Westward Ho, Phoenix, Ariz., March 6.

Fifth International Symposium on High Speed Testing, sponsored by Massachusetts Institute of Technology and Brooklyn Polytechnic Institute, Sheraton Plaza Hotel, Boston, March 8-9.

Marine Systems and ASW Conference, sponsored by the AIAA and the Navy, San Diego, Calif., March 8-10.

West Coast Symposium on Arms Control, sponsored by the American Ordnance Assn. and TRW Space Technology Laboratories, Los Angeles, March 8-10.

ntegrated Circuit Engineering Management, Design and Applications Seminar, sponsored by the Integrated Circuit Engineering Corp., Phoenix, Ariz., March 8-12.

National East Coast Meeting of the International Committee of the Aerospace Industries Assn., International Inn, Washington, D.C., March 9-11.

Workshop Seminar: Analysis of Viscoelastic Materials for Engineering Applications and Products Design, sponsored by the Plas-Tech equipment Corp., Boston, March 10-12.

article Accelerator Conference, sponsored by the IEEE, Shoreham Hotel, Washington, D.C., March 10-12.

Man-in-Space Symposium, sponsored by the Louisiana Psychology Assn., NASA Michoud Operations, New Orleans, March 12.

Third Annual Conference on New Horizons on Quality and Reliability, sponsored by the IEEE, Harpua College, Binghamton, N.Y., March 13.

nternational Symposium of the Solar Energy Society, Phoenix, Ariz., March 15-17.

os Angeles Chamber of Commerce Aerospace Committee Meeting, Los Angeles, March 16.

Advanced Planning Briefings for Industry, sponsored by DOD and NSIA, Americana Hotel, New York City, March 16-17.

Aviation and Space Conference, sponsored by the American Society of Mechanical Engineers, Statler-Hilton Hotel, Los Angeles, March 16-18.

Third National Inter-Service Data Exchange Program (IDEP) Conference, sponsored by the IDEP Contractor Advistory Board, in conjunction with the Army, Navy and Air Force, Albuquerque, N.M., March 16-18.

Spring Conference of the Electronic Industries Assn., Mayflower Hotel, Washington, D.C., March 16-19.

Third Goddard Memorial Symposium of the American Astronautical Society, Marriott Key Bridge Hotel, Washington, D.C., March 18-19.

International Convention of the IEEE, New York Hilton Hotel and New York Coliseum, New York City, March 22-25.

Second Microwave Symposium on Microwave Measurements, sponsored by Weischel Engineering, New York City, March 22-25.

Spring National Convention of the Society for Nondestructive Testing, Los Angeles, March 22-26.

22nd Annual Conference of the Western Section of the Society of the Plastics Industry, Hotel del Coronado, Coronado, Calif., March 24-26.

Convention of the American Society of Photogrammetry and the American Congress on Surveying and Mapping, Shoreham Hotel, Washington, D.C., March 28-April 3.

Advanced Planning Briefings for Industry, sponsored by DOD and NSIA, Conrad Hilton Hotel, Chicago, March 31-April 1.

Optical Society Meeting, Statler-Hilton Hotel, Dallas, March 31-April 2.

APRIL

International Symposium on Fission Product Release and Transport Under Accident Conditions, sponsored by the Oak Ridge National Laboratory, Oak Ridge, Tenn., April 5-7.

International Symposium on Techniques of Memories, Paris, April 5-10.

1965 Annual Region III Meeting of the Institute of Electrical and Electronics Engineers, Robert E. Lee Hotel, Winston-Salem, N.C., April 6-8.

1965 International Exhibition of Electronic Components and the First International Exhibition of Audio Equipment, Paris, April 8-13.

1965 Annual Region VI Conference of the IEEE, Las Vegas, April 13-15.

15th Annual National Telemetering Conference, sponsored by the IEEE, ISA and AIAA, Shamrock-Hilton Hotel, Houston, April 13-15.

Symposium on System Theory, sponsored by the Polytechnic Institute of Brooklyn, IEEE, Society for Industrial and Applied Mathematics, AFOSR, ONR, and the Army Research Office, New York City, April 20-22.

Advertisers' Index

AMCO ENGINEERING CO. 35
Agency—Buti-Roberts Adv.

APPLIED PHYSICS LABORATORY, THE JOHNS HOPKINS UNIVERSITY... 9
Agency—S. G. Stackig, Inc.

AVCO RESEARCH & ADVANCED DEVELOPMENT, DIV. OF AVCO CORP. 48
Agency—Benton & Bowles, Inc.

BOEING CO., THE.................... 38
Agency—Campbell-Ewald Co.

CBS LABORATORIES.................. 6
Agency—Harold Marshall Adv. Co., Inc.

DOUGLAS AIRCRAFT CO., INC......... 16
Agency—J. Walter Thompson Co.

GENERAL ELECTRIC CO., SPACECRAFT DEPT. 5
Agency—Deutsch & Shea, Inc.

HUGHES AIRCRAFT CO............... 47
Agency—Foote, Cone & Belding

MISSIMERS, INC..................... 36
Agency—Packard/Mitchell Adv., Inc.

PARKER SEAL CO..................... 4
Agency—The Lester Co.

SPERRY RAND RESEARCH CENTER, DIV. OF SPERRY RAND CORP........ 2
Agency—Reach, McClinton & Co., Inc.

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

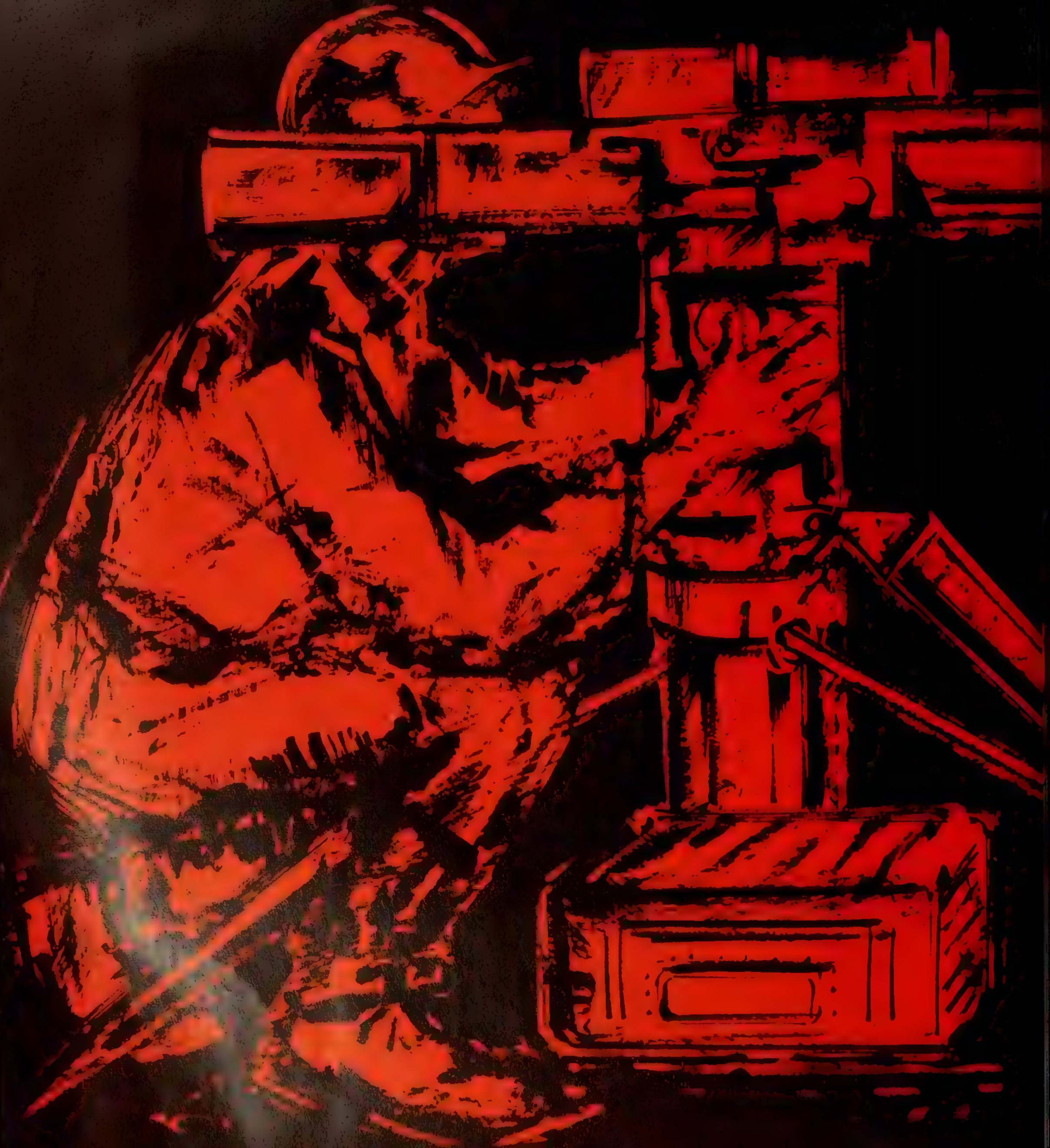
Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Paris, France—11 Rue Condorcet; TRU 15-39

MISSILES AND ROCKE

[illegible]



HIRD ANNUAL DOD ISSUE, March 29, 1965

advanced technology and the DOD

dvanced Technology is the key to growth n the future. The March 29 issue of MISSILES ND ROCKETS will concentrate on the pplications of advanced technology to actical warfare. It will encompass all phases f advanced technology for which the Defense and Space Industries have a unique apability and for which the DOD has nique requirements.

his issue will cover:

Advanced Technology: materials, electronics, power sources and basic research

Systems: combat support, air defense, command and control, mobility, and counter-insurgency

Plus these valuable guides:

Complete organization charts, procurement contacts and all defense level organizations involved in tactical warfare including DDR&E and ARPA.

Your advertising will have greater impact, greater importance and greater readership among the men making the important buying decisions in the military and industry.

LAN NOW TO CAPITALIZE ON THIS UNIQUE EDITORIAL ATMOSPHERE.

M/R

Advertising Closes: March 15, 1965

Issue Date: March 29, 1965

editorial . . .

An Unsolicited Proposal

NOW THAT *RANGER VIII* has written a second spectacular success story alongside that of *Ranger VII,* we want first of all to congratulate Jet Propulsion Laboratory. The California organization has done a fine job of bootstrapping a program marked by dismal failure into one of significant achievement.

Having said that, we would like to raise the unpopular question of just what *Ranger VIII* accomplished for the National Aeronautics and Space Administration—and more importantly, what *Ranger IX* will accomplish. We view *Ranger VIII* as a monumental waste of the taxpayer's money and believe *Ranger IX,* as presently programmed, will only repeat the folly.

The question which has not been asked about the latest *Ranger* shot, and which will apply equally well to its successor, is: What did it accomplish?

To reach a knowledgeable answer to this question, one must regard the three things *Ranger VIII* might have been expected to achieve:

- A significant input to the *Apollo* lunar-landing program, including the *Surveyor* lunar-lander vehicle.
- Advancement of scientific knowledge of the Moon.
- A propaganda coup of worldwide significance.

The most important of these by far is input to the *Apollo* project, which is the primary objective of the *Ranger* program. Yet, by almost any standard, the worthwhile contribution of *Ranger VIII* to the *Apollo* program is nil. As top NASA officials pointed out at the recent budget briefings, design of the *Apollo* vehicle, including the Lunar Excursion Module, has been frozen and production is proceeding. If this is the case, then *Ranger* information no longer is of value to *Apollo.* One of the highest officials in NASA has admitted this to be the case. There is nothing to be learned from *Ranger* regarding landing sites which cannot and will not be learned in ample time from *Surveyor, Lunar Orbiter* or *Apollo* itself.

Ranger VII increased man's knowledge of the Moon by several orders of magnitude. Yet, despite its magnificent photographs, the world's most distinguished lunar scientists still are arguing about the composition of the lunar surface. Dust, rock or lava? There are opinions, but no hard answers—and *Ranger VIII* was not programmed to seek an answer.

The best answer to this question would have been provided by photographs of the *Ranger VII* impact crater. This objective was suggested at a target meeting at JPL last November 19. It was rejected as having little likelihood of success. We do not believe JPL would have been condemned for an attempt to photograph the *Ranger VII* crater which failed. Even in the event of failure to hit the same target area, photographs just as valuable as those obtained by *Ranger VIII* would have been returned.

The decision, however, was not to go for the *Ranger VII* impact area but to attempt to improve the lunar model as a whole. Behind this was a belief that confirmation of *Ranger VII* discoveries in a different area would allow confident extrapolation concerning the Moon's geography.

If no information of direct value to *Apollo* were to be obtained, then what about *Surveyor?* Could *Ranger VIII* be of value in returning information on a landing site for *Surveyor?* A member of the *Surveyor* project team argued for this at the November 19 meeting and was overruled. The net result of these decisions was that little of value for the lunar-landing program was obtained with the *Ranger VIII* flight.

If no information was returned of urgent value to *Apollo*—that is to say, information that will not be available in ample time through *Surveyor*—then what of the second possible objective, advancement of scientific knowledge? It is true that *Ranger VIII* confirmed the findings of *Ranger VII,* although we fail to see why that is trumpeted as a discovery worth the millions of dollars which the shot cost. The hard, cold fact of the matter is that *Ranger VIII* added very little to the knowledge of the lunar surface—nor should it have been expected to. In any event, the advance in scientific knowledge will be repeated and multiplied manyfold by *Surveyor,* already far down the development path. At most, *Ranger VIII* has purchased a few years of time in obtaining knowledge of not very great significance.

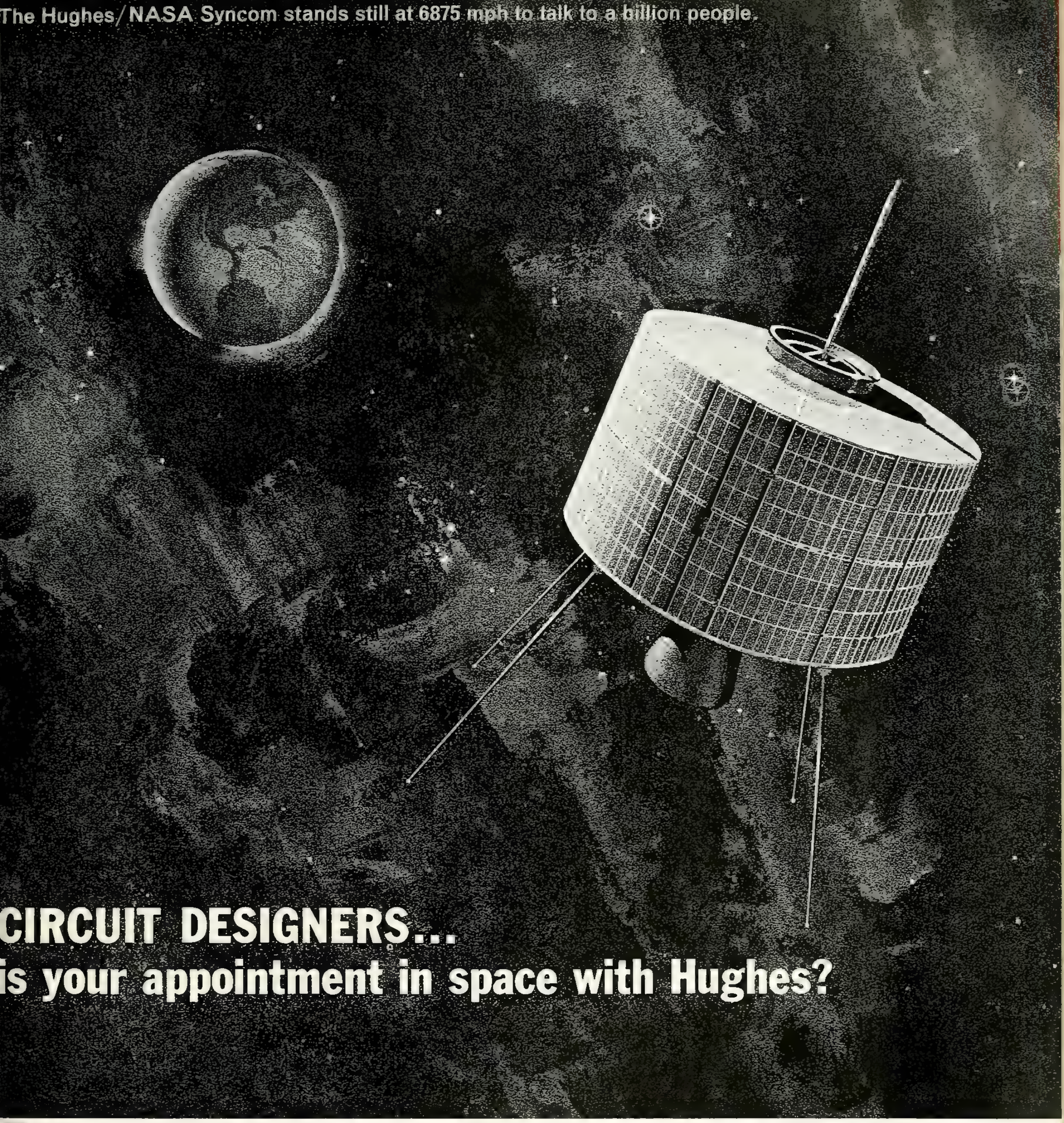
The third possible objective, that of a worldwide propaganda triumph, certainly was achieved. But again, because of the very success of *Ranger VII,* the accomplishment was diminished. It was a repeat of the earlier shot. To be sure, it was a textbook flight of which JPL can be very proud. But one need only compare the newspaper coverage of the two shots to see that a certain amount of the glamour had worn off.

MAGNIFICENT THOUGH IT WAS, the flight of *Ranger VIII* therefore must be written off as accomplishing little in relation to the time and expense involved. *Ranger IX, or Ranger D* as it is labeled prior to flight, now is set for launch from Cape Kennedy this month. Are we to repeat an expensive folly or is there some useful mission which can be performed?

There is indeed a mission for which *Ranger* might be adapted. Our unsolicited proposal to NASA is that *Ranger* be employed to return to Earth photographs of Earth from space. Satellites have told us the Earth is "pear-shaped" rather than round and that it draws a perhaps invisible but comet-like tail after it through space. Photographs of the entire Earth globe as seen from space would have high scientific value. As a propaganda triumph, it would be unequaled. The first nation to obtain such a photograph has assurance of front-page coverage throughout the world.

These are objectives far more worthwhile than those presently contemplated for *Ranger IX.*

William J. Coughlin


The Hughes/NASA Syncom stands still at 6875 mph to talk to a billion people.
CIRCUIT DESIGNERS...
is your appointment in space with Hughes?

Today, Hughes is one of the nation's most active aerospace/electronics firms. Projects include: F-111B PHOENIX Guided Missile System, TOW Anti-Tank Missile, SURVEYOR Lunar Spacecraft, SYNCOM, VATE, ARPAT, POLARIS, Hard Point Defense and others.

This vigor will assist the qualified engineers and scientists towards more and better opportunities for both professional and personal growth.

Many immediate openings exist. The engineers selected for these positions will be assigned to the following design tasks: the development of high power airborne radar transmitters, the design of which involves use of the most advanced components; the design of low noise radar receivers using parametric amplifiers; solid state masers and other advanced microwave components; radar data processing circuit design, including range and speed trackers, crystal filter circuitry and a variety of display circuits; high efficiency power supplies for airborne and space electronic systems; telemetering and command circuits for space vehicles, timing, control and display circuits for the Hughes COLIDAR (Coherent Light Detection and Ranging).

If you are interested and believe that you can contribute, make your appointment today.

For immediate consideration,
please airmail your resume to:

Mr. Robert A. Martin
Head of Employment
Hughes Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 33, California

Creating a new world with electronics

HUGHES

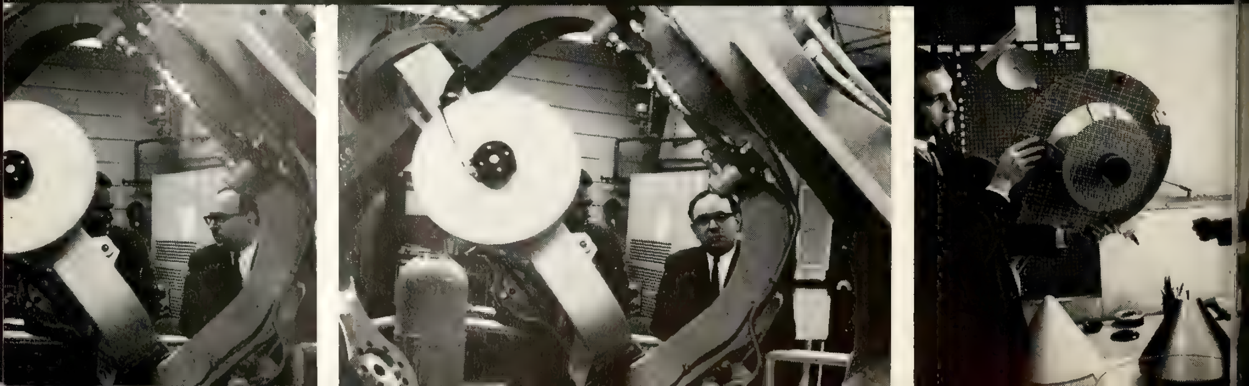
HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS
An equal opportunity employer.
U. S. CITIZENSHIP REQUIRED

Voyager Guidance & Control:

Putting a vehicle in orbit around Mars while landing another on its surface—advanced engineering at Avco/RAD. In a study for NASA's proposed Voyager program, our engineers faced these tough G&C requirements for the spacecraft: maintain proper orientation, with solar cells pointed to the sun; maintain attitude for the release and injection of the lander on a collision course with Mars; keep the communication antenna pointed toward earth; and point the mapping and scanning equipment towards Mars. Using a Canopus star tracker, sun sensor and inertial-attitude reference, we designed G&C systems which would allow the spacecraft to act as a "launching pad" for the lander, and then go into orbit around the planet. Such advanced design is only one of Avco/RAD's capabilities in research, engineering, manufacturing, flight testing, and overall program management. *That's what we mean when we say: Avco/RAD is an integrated research and development organization.*

AVCO/RAD

AVCO CORPORATION/RESEARCH AND ADVANCED DEVELOPMENT DIVISION/WILMINGTON, MASSACHUSETTS



MARCH 8, 1965

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

MAR 1965
HOUSTON PUBL

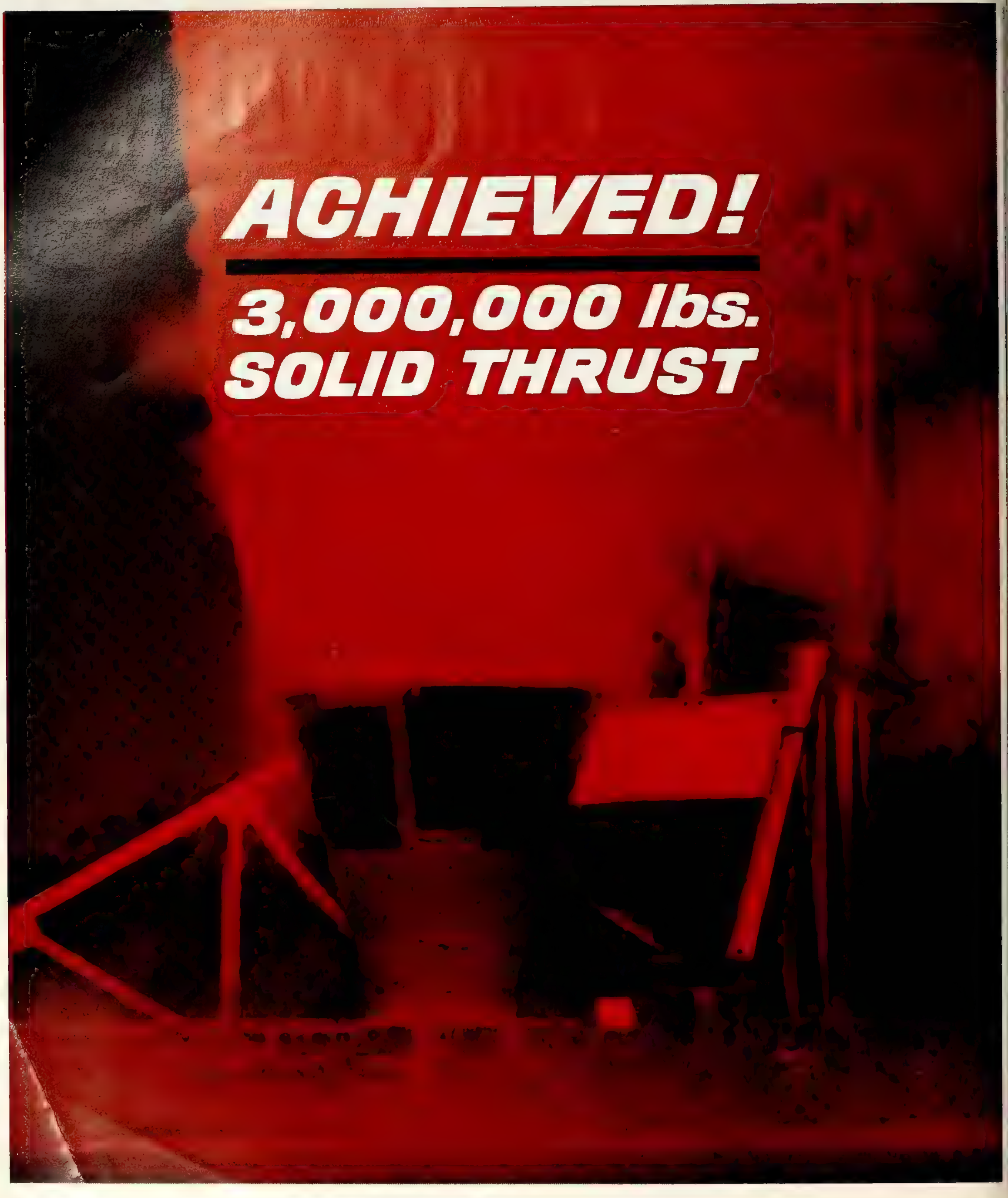
Martin SV-5 Model in Flight Test

NASA Cures Apollo's Shield Problem . .

156-in. Firing Raises Big Solid Stock . . .

Latest Edition of M/R's Astrolog . . . . .

.TION



WORLD'S MOST POWERFUL ROCKET MOTOR FIRED BY THIOKOL

Recent static tests demonstrating 1.2 million, 1.4 million, and now 3 million pounds of thrust offer proof that solid fueled motors can be scaled-up. They provide strong evidence that thrust up to 8-10 million pounds can be achieved from 260-inch diameter solid motors. Firing of the 3,000,000 pound thrust, 156-inch diameter motor accomplished test objectives, proved the nozzle design for 260-inch diameter motors, and demonstrated the monolithic motor concept for big solids. This is the second test conducted by the Thiokol Chemical Corporation as part of the nation's large solid booster program.

Thiokol
CHEMICAL CORPORATION
AEROSPACE CENTER: OGDEN, UTAH

Circle No. 10 on Subscriber Service Card

THE ASD RECRUITER

IMMEDIATE OPENINGS

ASD
APOLLO SUPPORT DEPARTMENT

COCOA BEACH, FLORIDA

Experience required in the following areas:

Telemetry Engineer BSEE	Three to five years experience in telemetry design or systems analysis and S Band, single side band, PCM/FM and FM/FM. Missile test site experience helpful.
Engineer—Digital Systems BSEE	Design and application of digital computer and transmission devices as applied to missile checkout and launch operations.

DAYTONA BEACH, FLORIDA

Experience required in the following area:

Computer Programmer BS Math, Engineering	Large scale computer programming of applied math and engineering problems. Experience in technical data processing and/or information systems desired.

HOUSTON, TEXAS

Experience required in the following areas:

Crew Systems Engineer BSAE, ME	Analysis of crew support equipment, environmental control system, controllers, space suits, and maneuvering units.
Simulation and Training Specialist, BSAE, ME, EE	Analysis of personnel training programs, interpretation and use of simulation data and evaluation of crew performance.
Space Environment Physicist MS Physics	Analysis of meteoroid environments, solar radiation and hard vacuum effects.
Senior Programming Analyst BS Math, Engineering	Computer programming and data analysis in flight mechanics and systems engineering including trajectory analysis and optimization.
Reliability Engineer BS Engineering	Design review and failure mode and effects analysis of solid propulsion systems and of missile handling and servicing.
Systems Engineer BS Engineering	Analyses and evaluation of spacecraft design and ground support electronic systems, propulsion and ordnance systems, and power generation and distribution systems.
Reliability Systems Engineer, BSEE	Systems engineering, including planning and conducting detailed design evaluation tests, environmental engineering tests, qualification tests or developmental flight tests, and analysis of test results.

HUNTSVILLE, ALABAMA

Experience required in the following areas:

Reliability Engineer—Systems BSEE	Design, test or analysis of electrical systems, with at least two years in failure mode and effects analysis, determination of criticality numbers, or development of math models.
Engineer—Component Documentation BSEE	Standardization and documentation of all components used in GSE, includes screening of parts for unreliability or obsolescence, compilation of qualified parts list, recommendation of testing programs, and coordination of unsatisfactory condition reports.
Electronic Systems Design Engineer BSEE	Conceptual, functional and preliminary design of electrical subsystems and hardware of ground support equipment for launch vehicles. Should include computer applications, digital circuitry or control systems design.

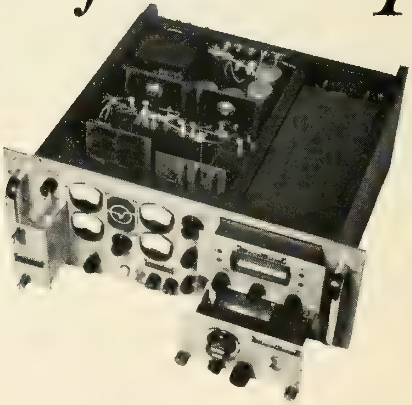
contact MR. D. D. SMITH / PROFESSIONAL & TECHNICAL RESOURCES
G.E. / Apollo Support Dept. / Room 1111-K / Box 2500 / Daytona Beach, Fla.

GENERAL ELECTRIC

An equal opportunity employer

Circle No. 1 on Subscriber Service Card

This is Vitro Electronics' Telemetry Receiver · It is Type 1037A · It is not new It is thoroughly field-proven · It is in its fifth production run · It is the standard for comparison



The 1037A is still the only advanced type telemetry receiver that is in full production with a long and successful history of field-proven performance and reliability. The 1037A offers a wide choice of off-the-shelf plug-in RF tuners covering a range of 55-2300 mc and the most versatile group of IF demodulators available which include true phase with long or short loop, linear phase for special PCM applications, phase tracking, high capture ratio, phase lock, FM and AM for all known telemetry formats. Integral plug-in predetection converters and spectrum display units optional. Improved adjacent channel rejection and optimum combination of RF nuvistors and solid state design avoid the dynamic range problems inherent in solid state RF tuner designs.

Vitro Electronics is also the only manufacturer with a complete line of off-the-shelf solid state pre- and post detection combiners, dual diversity receivers, up and down converters, multicouplers, preamplifiers, etc.

For a complete new catalog or additional details please write to
Vitro Electronics, 919 Jesup-Blair Drive, Silver Spring, Maryland.

Vitro

VITRO CORPORATION OF AMERICA · 90 PARK AVENUE · NEW YORK, N.Y. 10016

Circle No. 2 on Subscriber Service Card

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY
Volume 16, Number 10
March 8, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors
Charles D. LaFond................Electronics
William S. Beller................Engineering

Associate Editors
Lawrence J. Curran......Assistant Managing Editor
Heather M. David..................Space Medicine
Michael Getler.......................Electronics
John F. Judge................Propulsion/Materials
Robert L. Parker.....................Copy Editor
Rex Pay..............................Electronics
Hal Taylor..................................NASA
James Trainor...........................Military
Donald L. Zylstra........................Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach...................Art Director
Donald Strickland............Assistant Art Director
Suzanne Montgomery............Editorial Assistant
Sally Fosnight.....................Editorial Assistant

BUREAUS

LOS ANGELES.....9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks...................Bureau Chief
NEW YORK...................20 East 46th Street
Michael Getler
CAPE KENNEDY ....507 Orange Ave.
Merritt Is., Fla.
MIDWEST ....423 N. Quentin
John L. Zimmerman ....Wichita, Kan.
PARIS.........................11 Rue Condorcet
Jean-Marie Riche

EDITORIAL ADVISORY BOARD

Dr. Peter Castruccio
Alexander Satin
Conrad H. Hoeppner
Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton............National Sales Manager
Paul B. Kinney........Eastern Advertising Manager
Edwin J. Denker, Jr......Western Advertising Manager
Kenneth C. Blanchard.Marketing & Research Director
John N. Carlin..............Director of Circulation
Paddy Nelson................Circulation Promotion
R. Virgil Parker............Director of Production
Barbara Wiener........Advertising Services Manager

Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President.........................**Wayne W. Parrish**
Senior Vice President..............**Louis C. James**
Vice President.......................**Fred S. Hunter**

THE COVER

Model of Martin Co.'s SV-5 lifting-body re-entry research vehicle glides Earthward in recent flight test at Baltimore. Five-foot model is precursor of hypersonic vehicle, which eventually will be launched from Vandenberg AFB, Calif., over the Pacific. See story p. 15.

MARCH 8 HEADLINES

Four Companies Receive MOL Preliminary Study Pacts . 10
Atlas-Centaur Explosion Will Cause AC-6 Delay 10
Poseidon Project-Definition Awards Go to Three Firms . 10
DOD Industry Briefings in LA Off to Slow Start 12
Beefed-up Apollo Heat Shield To Undergo New Tests .. 13
MSC Apollo Chief Says Craft's Weight No Problem 14
LEM's Fuel Cells Will Be Replaced by Batteries 14
Martin Pressing SV-5 Lifting Body Program 15
156-in. Firing Success Bolsters Case for Big Solids 16
House Group Expected to Vote Funds for 260-in. Solid . 16

SPECIAL SECTION

Latest edition of M/R's Astrolog—a status report on all U.S. Satellites, Spacecraft, Space Vehicles and Missiles .. 21

SPACE BIOLOGY

NASA Will Use Fireflies in Plans to Map Biosphere 31

MANAGEMENT

Air Force Consolidates Role as Top Range Director 33

SPACE ELECTRONICS

Radiation, Inc., Developing System for Nimbus-B 35

DEPARTMENTS

Letters 6
The Countdown 9
The Missile/Space Week® 10
Technical Countdown .. 18
The Industry Week 37
Contracts/Procurements 40
Products & Processes .. 42
Names in the News ... 44
When and Where 45
Editorial 46

47,200 copies this issue

ENGINEERING WRITERS

The Applied Physics Laboratory, The Johns Hopkins University, has several attractive career positions available immediately for technical writers. Duties include preparation and publication of technical reports, documents and papers in close cooperation with the Laboratory's physicists, engineers and mathematicians.

Respondents should have broad technical interests and must be able to maintain a high professional standard of workmanship and accuracy. A degree in physics or engineering is required.

APL is located in a residential suburb of Washington, D. C., giving you a choice of city, suburban, or country living. Public schools in the area are excellent, and five nearby universities offer graduate courses.

Direct your inquiry to:
Mr. W. S. Kirby
Professional Staffing

Applied Physics Laboratory
The Johns Hopkins University

8643 Georgia Avenue
Silver Spring, Md.
(Suburb of
Washington, D. C.)

An equal opportunity employer

letters

Neuristor Article

To the Editor:

I found your recent article "NOL Develops Nerve-Like Diode" (M/R, Feb. 8, p. 14) most interesting and informative.

I am confident that anyone interested in the field of electronics could benefit greatly from learning more about neuristors. Consequently, I would like permission to publish your fine article in a forthcoming edition of *What's New in Electronics,* a bi-monthly publication which Cleveland Institute of Electronics distributes to individuals in administrative and engineering capacities within the electronics industry.

Ralph J. Schmotzer, Editor
What's New in Electronics
Cleveland Institute of Electronics
Cleveland, Ohio.

Thanks and permission granted.—Ed.

Libration Orbit

To the Editor:

U.S. intelligence reports show no evidence that the Russians are building anything nearly as big as the U.S. *Saturn V* (COUNTDOWN, M/R, Feb. 8). Yet all indications point to an advanced Russian lunar program. How come? The Russians have said they will use an Earth orbit method requiring less thrust. Could it be they plan to use the LIBRATION orbit? Russian hints point to this. Russia has stated that lunar orbit rendezvous would be too hazardous. Russia also stated that they intend to practice rendezvous in an Earth orbit far removed from Earth (the libration orbit is 220,000 miles from Earth). The Director of NASA's Launch Operations Center has stated: "The Russians claim that available boosters of about 820,000 pounds thrust (half that of our *Saturn C-1*) can be used. That may be true, but just how the USSR plans to carry out its objective with so little power remains to be seen." And, indeed, it may!

Most American scientists and engineers are unfamiliar with the libration orbit. Why? It is an almost stable Earth orbit in which a ship would always be on a direct line between Earth and Moon, about 33,000 miles from the Moon. This orbit would enable a manned lunar mission with no more thrust than that of the *Titan III-C*.

The libration orbit appears to provide the following advantages over the U.S. planned lunar orbit:

1. Much easier rendezvous.
2. Pre-parking of unmanned freight, shielding and modules. This freight, etc., can be maintained in the nearly stable libration center with very little power until arrival of the manned rendezvous ship. This feature enables use of low-thrust rockets.
3. Unlimited rendezvous and lift-off windows. The lunar orbit, on the other hand, is limited to dangerous windows of a few seconds duration.
4. Continuous line-of-sight communications between Earth, rendezvous ship and lunar landing crew. In the LOR method, on the other hand, the *Apollo* is shadowed from Earth half the time, and the lunar landing crew can communicate directly with the *Apollo* only a few minutes every two hours.
5. Better radiation protection.
6. Greatly improved safety factor because: 1. The manned ship need not leave Earth until it is known that all pre-parked supplies are available in working condition, at the libration center; 2. The decision to return to Earth can be made as late as arrival at this point only 33,000 miles from the Moon; and 3. Rendezvous is much simpler, with unlimited windows.
7. Reduced cost. An economy such as Russia's can afford the libration method, which will use many more rockets, but much smaller rockets already in "mass" production.

Perhaps the question should be asked: Why the abysmal ignorance of the libration orbit in the U.S.A.?

Thomas M. Morse
Santa Maria, Calif.

How Green My Stamps

To the Editor:

Your Feb. 15 editorial, "Cost Reduction," was funnier than you could know to a group of engineers in Grumman Aircraft You may enjoy the background story explaining why.

One of the men in my group, a fairly recent Grumman employee, rented a car from National on a trip. On his return he attached the stamps to his expense account with a note asking what Grumman policy was with respect to these stamps. Since nobody else had as much as asked the question before, I showed his report around as an example of the utmost in honesty. It created considerable interest and not a little laughter. Then, to satisfy my own curiousty, I made official inquiry, and was told to give them back to the man. When I asked him why he had raised the question, he explained that the small company where he formerly worked collected all such stamps, and used them to obtain small office supplies to the amount of $200-$300 worth a year. Hence he wanted to know company policy at Grumman, in case they did the same.

You can imagine how we reacted to your editorial.

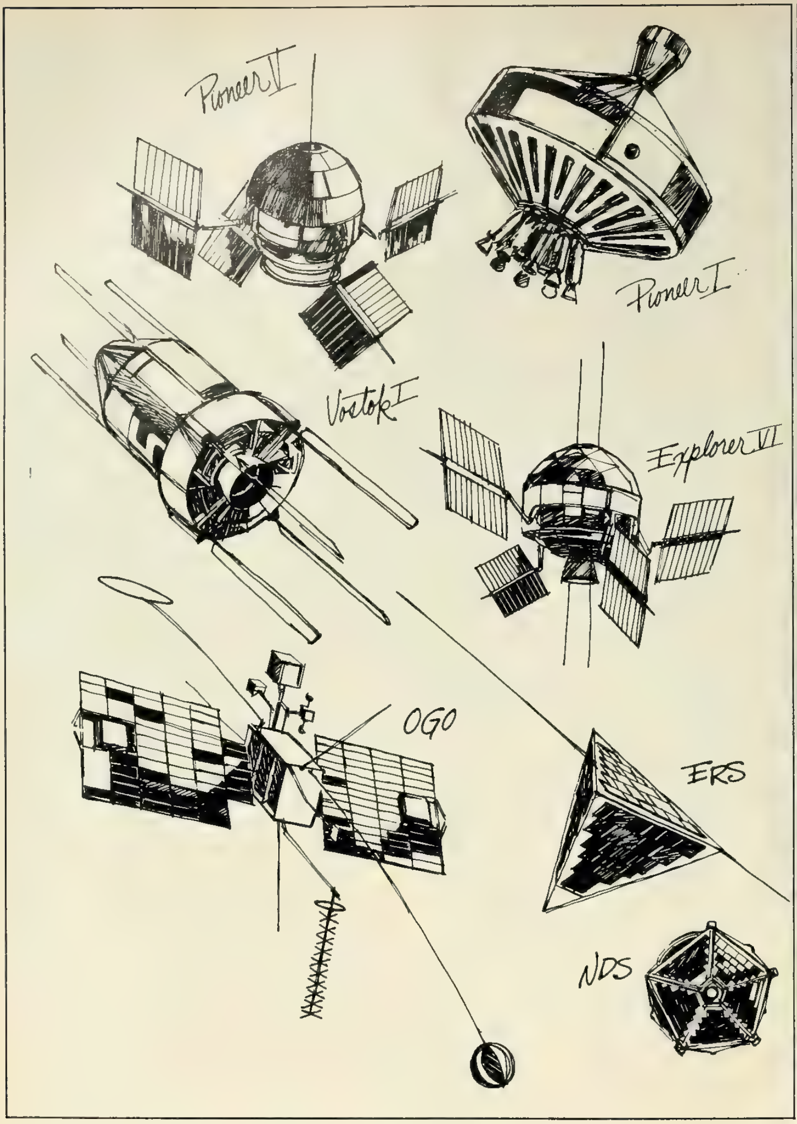
Incidentally, I find it reassuring that there are people in the world who are still so scrupulously honest as to ask what to do with the stamps. I refer to the man described above, not your mythical (I assume) Chuck X.

Edward Caldicott
Hempstead, N.Y

Gravity or Zero Gravity. Under state-of-the-art technology it's feasible to provide effective control subsystems for orbiting vehicles, which spin to produce gravity. Rigidly joined or cable-connected modules can be controlled by present techniques. Sperry has recently evaluated control methods to establish this. ☐ Zero gravity controls? Sperry has made intensive in-house studies of control needs for vehicles ranging from those with artificial gravity capability to those designed for weightless operation, with minimum control requirements... for scientific experiments ... and for military missions, from reaction jet to hybrid systems using momentum-exchange concepts. Leader in aerospace control and stabilization, Sperry offers reliable performance for these challenges in space. **GENERAL OFFICES, Great Neck, N. Y.**

SPERRY
DIVISIONS OF
SPERRY RAND
CORPORATION

Circle No. 4 on Subscriber Service Card



SOMEBODY ELSE BUILT THE VOSTOK

But TRW Space Technology Laboratories built all the rest. No other company has designed and built so many kinds of spacecraft for so many different space missions. Currently in production: Environmental Research Satellites, Nuclear Detection Satellites for Air Force-ARPA, and Orbiting Geophysical Observatory satellites and advanced Pioneer interplanetary spacecraft for NASA.

Today we are busy on many space projects that mean new opportunities for engineers and scientists. We are prime contractor for NASA's Orbiting Geophysical Observatory and Pioneer programs. We are developing the variable-thrust descent engines for Apollo and Surveyor lunar landings. And TRW Space Technology Laboratories continues Systems Management for the Air Force's Titan and Minuteman programs. These and other advanced space activities create opportunities in: Theoretical Physics, Systems Engineering, Radar Systems, Experimental Physics, Applied Mathematics, Space Communications, Space Physics, Antennas and Microwaves, Inertial Guidance, Analog Computers, Solid State Physics, Computer Design, Telecommunications, Digital Computers, Guidance and Navigation, Electromechanical Devices, Engineering Mechanics, Applied Aerodynamics and Propulsion Systems. For information about TRW opportunities in So. California and at Cape Kennedy, write TRW Professional Placement, One Space Park, Department MR-3 Redondo Beach, Calif. TRW is an equal opportunity employer.

Spacecraft above: Pioneer V, interplanetary probe, launched 1960; Pioneer I, lunar probe, launched 1958; Explorer VI, scientific satellite, launched 1959; ERS, environmental research satellite, launched 1962; NDS, nuclear detection satellite, launched 1963 and 1964; OGO I, orbiting geophysical observatory, launched 1964; Vostok I, manned Russian spacecraft, launched 1961.

TRW SPACE TECHNOLOGY LABORATORIES
THOMPSON RAMO WOOLDRIDGE INC.

655-A

The Countdown

WASHINGTON

It's Still the Moon Before '70—If

First *Apollo* lunar landing attempt could be made as early as the fifth manned flight with the *Saturn V* booster. Any landing flight coming prior to the eleventh manned flight will mean that the U.S. can still achieve its goal of landing a man on the Moon before 1970. NASA's new schedule for man-rating both the *Saturn IB* and *Saturn V* calls for two successive completely successful unmanned test flights before a manned flight can be made.

Slim Pickings, If Any, in Sight for M-1

The M-1 engine program is likely to get no more than a few million dollars, enough to continue component technology development, from the House Science and Astronautics Committee—if it gets anything at all. The committee tried to cut the program back two years ago, but the Senate restored some of the money. This year, complaints about Administration failure to allow NASA to request funds are not meeting with much sympathy among some House committee members, who have always felt that the program was operating at much too high a level.

Early Bird Gets the . . . Hold Signal

Defective transistor have forced postponement of the launch of the *Early Bird* synchronous communications satellite, which was scheduled for late this month. Communications Satellite Corp. has decided to replace and retest all transistors of a type found to be faulty during recent full-assembly checkout tests. A new launch date will be set after the retest program has advanced further.

Mariner Mars Power System Reliability

There's an estimated 0.711 probability that power supply on *Mariner IV* will operate successfully throughout the 6,213-hour mission. Estimated reliability of the *Mariner II* power system, which worked properly throughout the Venus mission, was 0.716. *Mariner's* figure actually shows a considerable improvement in reliability techniques, since a greater number of parts is involved and the mission is two and a half times as long.

Big Payoffs Seen from Oceanography

A National Academy of Sciences study estimates that a conservative investment in oceanographic research—about $165 million a year not counting defense expenditures—will yield a savings of nearly $3 billion a year in the national economy plus added annual production worth almost that amount. In a period of 10-15 years, it is believed that with reasonable Federal support an annual $6 billion can be realized.

INDUSTRY

NASA-DOD Industry Liaison Office Set Up

NASA has announced establishment of a NASA Industry Affairs Office (Pentagon) for liaison with DOD in matters concerning both agencies. The space agency's new Pentagon office will be "concerned with procurement, quality control, contract administration, industrial facilities and related subjects." Primary point of contact for the new office within DOD will be the office of the Assistant Secretary of Defense (Installations and Logistics).

$1 Million Plus for New Apollo Studies

Manned Spacecraft Center has asked Grumman, North American and Boeing for more than $1 million worth of new Extended *Apollo* studies. NAA was told a maximum of $400,000 was available to cover new studies of experiments in the Command and Service modules, A like maximum was given Grumman for proposals covering experiments that could be integrated with the Lunar Excursion Module. Boeing was told that the Center has $300,000 available to prolong and expand study of potential experiments in the Extended Laboratory Module design now being undertaken by that company.

Additives To Be Studied for Service Module

Marquardt Corp. has been given until March 15 to propose a program to test rocket fuel additives for their effect on ignition "to eliminate or reduce vacuum ignition pressure spikes" in *Apollo*'s Service Module. Firings will take place for each of 11 additives in a vacuum chamber at a simulated 100,000 ft. Measurements will cover history of pre-ignition pressure time, maximum transient pressures and ignition delays.

UTC Investigates Recovering Titan Strap-ons

United Technology Center is looking into the feasibility of recovering *Titan III-C* strap-on boosters. Ground firing tests of the 120-in solids have shown a high degree of reusability. Use of the *Titan III-C* would have to be stepped up considerably, however, before the economics became worthwhile.

Overseas Booster Market Opening

U.S. manufacturers may now have a substantial opportunity to sell boosters in Europe, according to NASA Deputy Administrator Dr. Hugh L. Dryden. Special need is for a medium-weight satellite launch capability between the *Diamant* (analogous to *Scout*) and *Europa I* (about 2,500 lbs. in near-Earth orbit). Rep. Joseph Karth (D-Minn.) suggested almost two years ago that steps be taken to enable U.S. contractors to market space boosters abroad.

INTERNATIONAL

French Schedule $61.4-Million 1965 Outlay

France is committing about $61.4 million dollars to its own space program, the European Space Research Organization (ESRO), the European Launcher Development Organization (ELDO) and the French Space Administration (CNES) during 1965. The total breaks down as: $16,200,000 for ESRO and ELDO; $4,200,000 for CNES; $7,000,000 for technical research; $2,400,000 for sounding rockets; $7,000,000 for the *Diamant* launcher; $800,000 for scientific satellites; $7,300,000 for tracking network; $5,900,000 for testing technical equipment; $2,800,000 for calculation center; $1,000,000 for Bretigny-sur-Orge Center; $2,100,000 for Guiana Launch Base; $2,100,000 for CNES headquarters, Paris; $800,000 for re-evaluation of process; and $1,800,000 for taxes.

The Missile/Space Week

MOL Design Studies Let

Four firms were awarded preliminary design studies in the *Manned Orbiting Laboratory* (*MOL*) program, Mar. 1.

Selected from a list of seven companies submitting proposals were Boeing, Douglas, General Electric and Lockheed. Each contractor will undertake a 60-day study at a reported contract figure of $400,000.

AC-6 Delayed By Blast

Space agency officials estimate that the explosion and destruction of the *Atlas-Centaur 5* Mar. 2 will probably delay the sixth flight in the series by a month or two.

They declared that it will not delay the first attempt to soft-land a *Surveyor* spacecraft, which could be made as early as the *AC-7* mission now scheduled for late fall.

After preliminary inspection of the launch complex, which was badly damaged, NASA immediately ordered work to begin to complete Pad 36 B, which is also designed to launch the *Atlas-Centaur* combination. This pad is 90% completed and officials estimate that it will take about another month to get it ready for flights.

The pad A in the complex was heavily damaged—primarily by heat—when *AC-5* settled back on the pad about two seconds after lift-off with a resulting explosion. NASA said that the *Atlas* two first stage engines for no apparent reason shut down shortly after lift-off.

Flames envelop Atlas-Centaur 5.

Four engineering analysis teams composed of NASA and General Dynamics were named to study the *Atlas* propulsion, electrical and guidance data launch vehicle development and pad damage. They will attempt to find out what caused the unsuccessful flight and how much damage was done.

The *AC-6* flight, which is now expected to be made in the July-August period, will carry another dynamic model of the *Surveyor* spacecraft. The first engineering spacecraft with a capability of landing on the Moon will be launched on the seventh *Centaur* flight.

NASA Repositions Syncom II

NASA has moved the *Syncom II* spacecraft to a new position over the Indian Ocean at the request of DOD, which is now charged with operational control of the satellite.

From its previous position over Brazil, the satellite was moved to a new position at 68° east longitude over the Indian Ocean. With *Syncom III* already in orbit over the Pacific Ocean, the new shift gives DOD two satellites on which to channel its communications with the Far East.

Poseidon PDP Awarded

Three-month contracts for project definition phases in both stages of the *Poseidon* (*Polaris C-3*) propulsion systems probably will be signed with Hercules Powder Co., Aerojet-General Corp. and Thiokol Chemical Corp.

The contracts amount to about $4 million each. Proposals were submitted to Lockheed Missiles & Space Co., prime contractor on the *Poseidon* weapons system.

$17.3M Sought for AAFSS

To implement sorely needed *AAFSS* (*Advanced Aerial Fire Support System*) effort, $17.3 million in initial funds for engineering development is being requested in FY 1966.

Dr. Harold Brown, DDR&E director agrees that "there is little question that improved systems of weapons and avionics are required"—the weaponry whether a new aerial vehicle is needed or not.

Army proposes to use the *TOW* or *Shillelagh* antitank weapons on their adaptations as armament for an *AAFSS* helicopter. Winners of the Army PDP contract for this system are Lockheed California Corp. and Sikorsky Aircraft Div. of United Aircraft, but no formal award has been announced.

AF Seeks Titan III Money

The Air Force is requesting $94.6 million in FY 1966 for continuing research and development in the stretched-out *Titan III* family of boosters.

Although the program is "tightly controlled and is meeting all its major milestones," the stretchout of at least a year was ordered to permit a "logical phase-in" of the *MOL* flight program and to give greater opportunity to other potential users of development launches.

Grumman Wins Factors Study

Grumman Aircraft Engineering Corp. will study human factors affecting operation of manned roving vehicles on the lunar surface under a contract expected to be announced shortly by NASA's Marshall Space Flight Center.

The study, expected to take about eight months and valued at just under $100,000, will make test use of the experimental lunar surface vehicle previously developed by Grumman (M/R, Oct. 15, 1962, p. 24) and the firm's fixed-base TV simulator.

Chrysler Gets $41.2-M Pact

The John F. Kennedy Space Center has awarded a $41.2-million contract to Chrysler Corporation for launch and support responsibilities associated with the *Apollo* program and *Saturn I/IB* launch operations.

It covers the support launch operations for the two *Saturn I*, and 1 *Saturn IB* space vehicle flights.

Mariner Changes Revealed

Two *Mariner IV* experiments have experienced operational changes recently.

Dan Schneiderman, *Mariner* project manager for NASA's Jet Propulsion Laboratory, said data from the solar plasma probe, which ceased normal functioning early in December now has become understandable to scientists through analysis of a component failure in the probe.

He also said that a portion of the ionization chamber experiment, which measures radiation in space, is not operating properly.

The new failure, he said, is in the Geiger-Mueller tube, which counts the number of charged particles in the energy region measured by the ion chamber.

The chamber itself, which measures the total effect of radiation in the region of energy of electrons greater than 0.5-million electron volts and protons greater than 10-million electron volts, continues to function normally.

Malfunction of the Geiger-Mueller tube portion of the experiment was ascertained after several days of analyzing data that did not fall within predicted levels and could not be correlated with other measurements.

Boeing Submits ASMS Bid

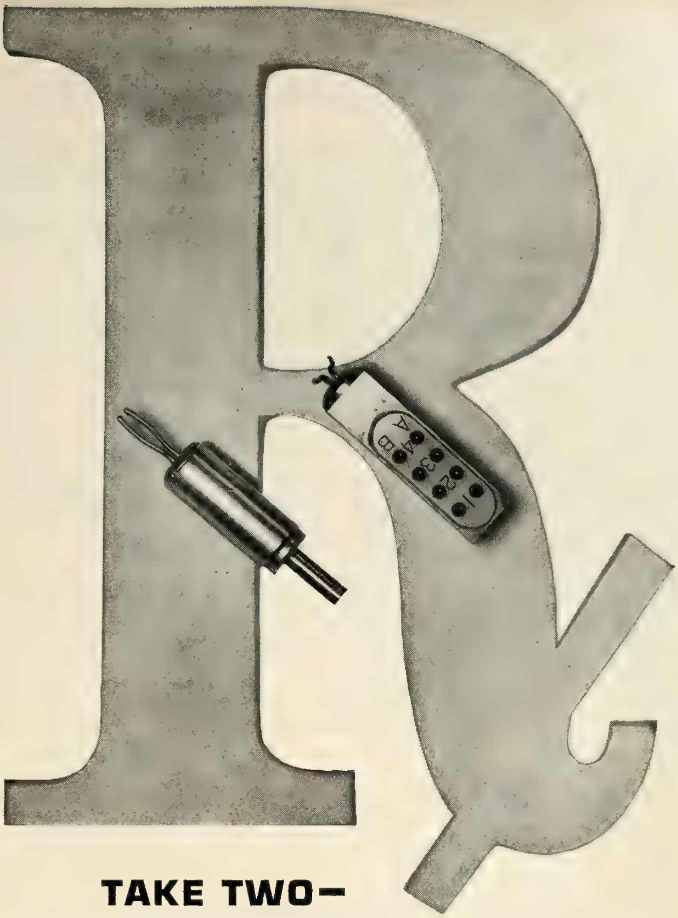
The Navy's Bureau of Weapons has received Boeing's project definition phase study for its *Advanced Surface Missile System (ASMS)*.

Besides Boeing six other firms—GE, Hughes, Raytheon, RCA, Sperry Rand and Westinghouse—are preparing studies in their bid for the *ASMS*.

Shots of the Week

An Air Force crew launched a *Minuteman* ICBM from a silo near Newell, N.D., on Mar. 1 (see M/R, Mar. 1, p. 8) in the first inland test of the missile. All other shots have been from either Cape Kennedy or Vandenberg AFB, Calif.

- *HIBEX*, the high-acceleration experimental missile booster sponsored by the Dept. of Defense Advanced Research Projects Agency and the Army, was successfully flight tested Feb. 25 at White Sands Missile Range, N.M.
- The Soviet Union on Feb. 26 launched *Cosmos 58*. The satellite carried a radio transmitter operating on a frequency of 90.022 mc.
- The Air Force on Mar. 1 launched a *Minuteman* ICBM more than 5,000 mi. down the Western Test Range from Vandenberg AFB, Calif.
- The *Atlas-Centaur* that was to have boosted a dummy of the *Surveyor* lunar lander Mar. 2 exploded at Cape Kennedy (see p. 10).
- Atlantic Research Corp. has announced that the *Frangible Arcas* meteorological sounding rocket it developed for the Air Force has successfully passed flight tests at the Western Test Range.



TAKE TWO—
THEY'RE HARMLESS

They're examples of Atlas explosive-actuated components and systems. Switches, actuators and specialty devices designed to open or close a circuit or move a mechanical load . . . more reliably . . . with less weight . . . in a smaller space . . . and with lower power requirements than any other type of relay or actuating mechanism.

Explosive-actuated devices are powerful for their size, but their power is completely controlled. The entire "explosive" reaction is self-contained in a hermetically sealed unit. They don't blow up; the casing doesn't rupture; the expanding gas is contained.

Atlas explosive devices offer an unbeatable combination of reliability and miniaturization. Think of this the next time you are working on a one-time performance system.

Why not investigate the full design potential of explosive-actuated devices and systems? Call us today. Or send for literature containing characteristics and specifications.

ATLAS
CHEMICAL INDUSTRIES, INC.
Aerospace Components Division
Valley Forge, Pa. 19481

Circle No. 5 on Subscriber Service Card

Hall tells industry briefing . . .

Cost Key to Military Man-in-Space

DDR&E official says usefulness of man in orbit is established; he cites $6.5-billion annual R&D budget; Zierdt outlines Army needs

LOS ANGELES—Because of the costs involved in sustaining and protecting man in space, "we have not yet proven that his unique capabilities of judgment and discrimination should be exercised in orbit," Dr. Albert C. Hall, Deputy Director of Defense Research & Engineering for space, declared last week.

"The question seems to be one of cost and not of man's usefulness," Hall said in an address on March 3 at the Dept. of Defense advanced planning briefings for industry. "Should man exert his capabilities directly, or remotely? seems to be the fundamental question."

- **Slow start**—In general, industry representatives to the first such briefings conducted by DOD in nearly three years felt vaguely disappointed. Larger firms and major prime contractors did not find much of value in the first day of the unclassified sessions. Smaller firms, particularly those removed from the West or East coasts, found the sessions more rewarding.

The usual reaction was to shrug off the liberal amounts of material on improvement of management techniques and the Pentagon's perennial cost-reduction program. Industry people attending primarily in the hope of learning about new business opportunity tended to become somewhat impatient.

- **Satellite inspection**—In his address, Hall noted that one of the most demanding space problems of the next decade will be the development of devices for inspecting potentially hostile satellites. Again, he said, cost is a factor in solving this problem. "If it should cost several times more to launch a satellite inspector than it cost to orbit the suspicious satellite" answers would have to be supplied to at least three questions, Hall said: 1) How important is it for us to inspect these vehicles and what surprise may be in store for us if we do *not* inspect? 2) Of the several hundred objects now in orbit, how should we sort out those that we want to inspect? 3) If we find something we don't like, what do we do about it?

Hall noted that in answering the third question, the United States was led "to establish an operational anti-satellite capability," as announced by President Johnson last year.

"Today we have no weapons deployed in space, and it seems unlikely that we will deploy such weapons in the future," Hall said.

"There are uncertainties in the budget because there are uncertainties in the operational needs, and there are uncertainties because there are technical unknowns," he emphasized. Hall observed that if the military research and development budget remains at its current $6.5-billion annual level over the next 10 years, "we would . . . be discussing military technology supported by a total obligation of $65 billion dollars. This sum is more than we have spent in the aggregate on military technology since the founding of this country."

- **Nike progress**—In discussing the potential and the unresolved needs of the *Nike-X* effort, Hall noted that unless the interceptor missile can reach the target very rapidly, the defense cannot make use of the atmosphere to help distinguish between true and false targets. "However, when interceptor times have been reduced to a certain point there is little to be gained by further reductions," he said.

The Advanced Research Projects Agency's *HIBEX* program is making its contribution toward *Nike-X* technology by pointing the way toward improvements in the *Sprint* missile. Project Defender, another ARPA responsibility, is studying the possibility of anti-missile approaches which "may allow intercepts at greater range than our current terminal system," Hall said. "Relatively small improvements allowing us to push back intercepts from after to before atmospheric re-entry might pay off handsomely in system effectiveness." The Defender program is currently funded at about $130 million annually—largest single item being support of re-entry measurements.

- **Army interests**—In outlining Army's achievements and future needs in the missile field, Army's Maj. Gen. John G. Zierdt, Chief of the Army Missile Command observed that "we have built the systems we knew how to build." Although the military services have a long way to go before they exhaust the potential of the guided missile, "we must have a real reason before we begin a new system," Zierdt said.

Zierdt said he saw future procurement potential totaling "more than three-quarters of a million dollars" in the next few years, if three new Army missile systems are developed successfully. He mentioned: 1) the *Redeye* air-defense guided missile, now phasing into production; 2) the *TOW* wire-guided anti-tank missile system, launchable from vehicles or from fixed ground mounts; and 3) the *Lance* ballistic missile, being developed as Army's new division support weapon.

If industry can come up with the proper solution to Army's future missile needs, there are five areas where Zierdt sees potential new weapons systems: 1) defense against ballistic missile attack, where the *Nike-X* solution to the problem is well advanced; 2) field-army defense against attack by aircraft and short-range tactical missiles; 3) an effective anti-tank missile beyond *TOW*: 4) a satisfactory large free rocket, with much-improved accuracy; and 5) multipurpose missiles that can be used against several types of targets (such as air or ground) without delay in changing from one mode to another.

In developing its approach to the solution of the field air defense problem, the Army chose to call its *AADS-70* effort the *"SAM-D"* program for the first time. DDR&E sources noted that this designation was chosen rather than *AADS-70* because the *SAM-D* effort promises a less complex, more satisfactory solution to the problem. But spokesmen readily acknowledged that *SAM-D* is an outgrowth of the *AADS-70* concept. ■

Toughest problem yet . . .

Redesigned Apollo Shield Gets Tests

November drop test revealed original heat shield was too weak to resist water impact; boilerplate Apollo sank in four minutes

by Hal Taylor

HOUSTON, TEX.—Space agency officials believe they have solved the severest technical problem yet encountered in Project *Apollo*.

A series of tests this week at North American Aviation, Inc., Downey, Calif., plant will tell them if they are right.

The problem was first discovered last November, according to Dr. Joseph Shea, director of the *Apollo* spacecraft project at the Manned Spacecraft Center. An *Apollo* boilerplate model—during a series of drop tests into a water tank under simulated maximum re-entry conditions—sank in four minutes after its heat shield, under the force of the impact, sheared and pierced the cabin.

Dr. Shea told MISSILES AND ROCKETS that during the impact a simulated astronaut within the spacecraft suffered forces equal to 50 g's. In addition, the quickness with which the spacecraft sank below the water made it highly unlikely that astronauts could have gotten out alive.

Space agency officials here immediately ordered additional design studies to solve the problem, which they said was the fault of poor engineering computations by both NASA engineers and the industrial contractors. After a series of scale model tests at the Langley Research Center and other drop tests at NAA, it was decided to beef up the heat shield structures to withstand the heavy impact loads, which reached pressures of 300-400 psi during the November test.

To strengthen the heat shield, it was decided to increase the thickness of its honeycomb core by a factor of three. At the same time, the size of the face sheet was increased over the 0.008-in. stainless steel that had been used previously. The new face sheets which have been bonded to the honeycomb are 0.05, 0.03 and 0.015 in. thick.

SATURN V TEST model is boosted into recently completed 400-ft.-high static test stand at Marshall Space Flight Center. The 200,000-lb. model, 138 ft. long and 33 ft. in diameter, was assembled in an area 1½ mi. away and moved to the test site Mar. 1. Five 10-ton F-1 engines, developing a total of 7.5-million lbs. of thrust, will be mounted on the stage after it is placed into stand. Firings are due to begin this spring.

The modifications added an additional 350 lbs. to the Command Module weight. Shea said that it would not delay the first flight spacecraft, which is still scheduled to be launched early in 1966. Any schedule slippage will be avoided by delaying the installation of the new heat shield until after the integrated spacecraft systems testing is completed. He said that the problem was caught and a solution found early enough in the program so that no other flight spacecraft will be delayed.

- **New test this week**—Shea said that the test program slated at NAA this week will determine whether the new heat shield structure is strong enough. He said that two tests in the last couple of weeks have been successful. Next week's test will have the spacecraft impacting at a speed of 35 fps and an impact angle of 16 degrees.

This is close to the November test conditions, when the impact speed was 40 fps at an angle close to 13 degrees.

This week's test parameters will be sufficient for the first flight test because NASA plans to reduce the allowable sea conditions, impact force and angle.

An astronaut on a nominal re-entry would not encounter the severe conditions simulated in NASA's maximum re-entry tests which approach the 40 fps speed and a 10- or 11-degree angle.

This would occur only if one of the parachutes failed, there was a maximum horizontal wind speed of 30 knots, a wave slope of about 8 degrees and a spacecraft swing angle of 26 degrees.

Dr. Shea says that he has complete confidence in the ability of the *Apollo* heat shield to protect *Apollo* astronauts against the extreme re-entry heating conditions. The *Apollo* heat shield ablative material tested during a series of *Scout*-boosted re-entry tests last August was 1¼ in. thick and was expected to char down to 1.15 in. Results of the test showed that the heat shield survived and that it charred down to 1.1 and 1.15 in. ■

Still room for growth . . .

Apollo Weight Problems Discounted

MSC program chief says current weight below goal; points to additional Saturn V capability as further cushion

A TOP NASA official declares that rumors that the *Apollo* spacecraft is having weight problems are untrue and that the current weight is well under the goal of 90,000 lbs.

Dr. Joseph Shea, director of the *Apollo* spacecraft program at the Manned Spacecraft Center in Houston, said that the current weight of the Command, Service and Lunar Excursion modules is about 89,900 lbs. He added that there is still room for additional growth because the *Saturn V* booster now has an estimated payload capability of 95,000 lbs. for its lunar missions.

The Block 1 command modules—which have a design weight of 11,000 lbs.—now weigh about 10,400 lbs. according to last reports. The service module for the first flight spacecraft has a design goal of about 9,300 lbs. and it weighs about 8,360 lbs. These are all inert weights.

The second flight spacecraft command module also has a design goal of 11,000 lbs., and it currently weighs about 9,850 lbs.

The Block II spacecraft—which will be used for the first manned flights scheduled to be made in late 1966—are also holding to planned weights, according to Shea.

The command module weight goal is again 11,000 lbs. and thus for the expected weight is set at about 10,100 lbs. The service module design weight is 10,200 lbs. and the current weight estimate is 9,900 lbs.

The lunar excursion module weight has been growing but this is principally because it is still in the early development stage.

- **LEM weight increasing**—He said that the LEM weight has been set at 29,500 lbs. and it is currently approximating 29,200 lbs. At the same time, he said that the LEM is going through a new evaluation which may raise its weight to as much as approximately 32,000 lbs.

He said that new evaluation stemmed from a NASA decision to make that spacecraft as safe in terms of redundancy as the Command and Service Modules.

Shea added that he saw nothing in the future in terms of possible technical problems or systems changes that would indicate the weight of the spacecraft will be a major problem for designers.

In other areas of the *Apollo* program Shea said:

—The space agency has chosen a stable baffled injector for the Service Module's propulsion system and it is currently going into a qualification test program. He said that the new injector would be replaced in two engines being fired at White Sands, N.M. He said he expects the propulsion system to pass its preliminary flight rating test by the end of April.

—Communications system equipment for the spacecraft will be delivered late, primarily because of changes in the system and the large number of firms involved in the communications part of the project.

—Recent tests of the headshield in re-entry tests with the *Scout* booster achieved a high total heat of 250 Btu's per square ft. This is about 80% of the heat expected to be encountered during return from the Moon. ■

Batteries Will Sub for LEM Fuel Cells

NEW YORK—NASA has decided to replace the fuel-cell power subsystem aboard *Apollo's* Lunar Excursion Module with a more conventional battery system, MISSILES AND ROCKETS has learned. The decision is not likely to be made public for another 30 days, however.

Motivation for the move is reportedly linked to NASA's special concern for having equipment with the best possible reliability aboard LEM for the highly critical lunar-landing mission. Officials say that mission, as currently planned, is still of short enough duration (48 hrs) to allow use of proven, high-performance and high-reliability batteries. Project sources say there is little doubt that for longer-duration missions, only a fuel cell would be acceptable.

A decision to remove the cell from LEM will not affect use of the same basic unit aboard the *Apollo* Command Module. The hydrogen/oxygen cell is being developed by the Pratt & Whitney Div. of United Aircraft Corp. The *Apollo* cell has recently operated successfully in extensive tests at P&W (see page 18). Program spokesmen say the LEM cell was expected to have completed its qualification program sometime later this year.

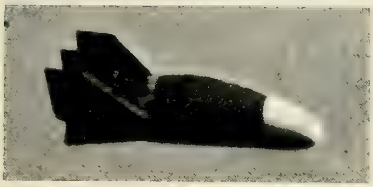
- **A la Gemini**—While the fuel cell is now to be removed, at least for early missions, project officials hold open the possibility that the unit could go aboard later LEM spacecraft. The situation wauld be somewhat analagous to the *Gemini* program, in which batteries will be used for early manned flights, eventually to be replaced by fuel cells (M/R, June 8, p. 29). During the next few weeks, NASA and Grumman officials are expected to work out many of these future possibilities, in addition to possible battery system configurations.

One battery configuration being considered involves six units, four in the descent stage and two in the ascent stage, for complete redundancy. Each battery would reportedly have about an 80 watt/hr./lb. rating. The silver-zinc type of battery, such as that being used in *Gemini*, is said to be one of the prime candidates. Overall system weight would be roughly equivalent, officials say, including some additional life support made necessary by the loss of the water by-product through removal of the fuel cells.

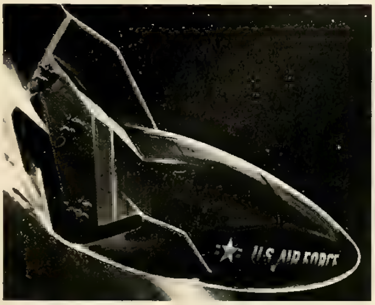
Under AF START contract . . .

Martin Developing SV-5 Lifting Body

Three-year contract progressing toward hypersonic test vehicle of man-carrying size for Pacific flights; eventual ground landing implied



TOP: Small model of Martin SV-5 lifting body in flight over Baltimore Div. airport after release from hydrogen balloon. More than 50 flights have been made with 5-ft.-long model weighing about 4 lbs., slightly more angular in configuration than final design for START program. ABOVE: Two balloons lower model to ground for reuse. BELOW: Artist's conception of SV-5 to be flown over Western Test Range. Vehicle will not have center fin used on model.



PHOTOGRAPHS RELEASED Mar. 3 revealed the current configuration of the Martin Company's *SV-5*, a maneuverable, lifting-body re-entry vehicle now undergoing a three-year testing program under an Air Force contract. More than 50 flights already have been made with the earliest version of the *SV-5*, featuring three vertical stabilizers and a more angular design than the current model, which has only two vertical fins.

The Martin contract, expected to call for eventual expenditure of about $35 million, was first announced in August, 1964, and is the first prime award under the START (Space Technology And Re-entry Test) program. The series of START tests has been scheduled as a follow-on to the *ASSET* program, which logged its sixth and perhaps final launching Feb. 23 (M/R, Mar. 1, p. 12).

Launched from a hydrogen balloon and lowered to the ground after flight by balloons, the early *SV-5* models are the smallest of a series of test vehicles which will eventually reach a size capable of carrying a man. The first three-vertical-fin model is 5 ft. long and weighs about 4 lbs. Nineteen of the first 50 flights saw the vehicle guided by a three-axis, ground-controlled proportional radio control system.

- **The choice**—Gen. Bernard A. Schriever, Air Force Systems Command chief, described the START program, of which the *SV-5* is a part, as a "fourfold research spacecraft program to develop unmanned test vehicles capable of maneuvering to a precision recovery site after re-entering from orbit."

Addressing the American Management Association in New York, Schriever noted that present-day military systems management poses two questions: "Do we want to use today's technology and hardware to build a product that may be equal to or perhaps marginally superior to our competitor's? Or, do we want to assume a certain risk and build a product which requires some new technology but which will be definitely superior to the products our competitors are building?" By developing technological rather than hardware building blocks through programs such as START, Schriever asserted the U.S. would be best able to maintain its technological weapons superiority.

The *SV-5* program will mark the first U.S. hypersonic flight tests of maneuverable lifting body re-entry vehicles, with speeds of more than 17,500 mph as the ultimate goal. Although the Martin-built vehicles will have no propulsion plant in the usual sense, being launched by an *Atlas SLV-3* booster from Vandenberg AFB over the Western Test Range, they will have gas attitude-control jets for use in space and early phases of re-entry.

Horizontal control surfaces beneath the boat-tail stern of the spacecraft are in the form of elevons, used differentially for roll control and as a unit for pitch control of the *SV-5*. The vehicle has two fixed top flaps. A special ablative coating on the *SV-5's* exterior and control surfaces is described as a "rubbery honeycomb material" applied over conventional aluminum skin and vehicle structure. Design anticipates heats up to 3,000°F.

- **Land recovery?**—More than a dozen shapes were built and tested before the present *SV-5* configuration was chosen for the initial 50-test series. Its early development, using the *Atlas SLV-3* booster, will involve parachute recovery over water. But the large eliptical landing "footprint" for which the craft is being designed implies eventual landings on land, at pre-selected sites. One of Martin's high-lift-drag ratio designs contemplated an 8,000-mi.-wide footprint. But early *SV-5* flight-test models will be limited to a choice of landing area considerably more restricted.

The *SV-5* configuration was developed by Martin under an earlier government contract covering the Martin M-103 re-entry design. This contract was one of two in a competition between Martin and GE to develop a recoverable re-entry body for *SAMOS* surveillance satellites. ■

'Unqualified, unequivocal . . .'

156-in. Firing Scores Major Success

Impressive firing of world's largest motor raises hopes for more funding; 260-in. motor nozzle comes through in excellent condition

by John F. Judge

HORSE PEN BLUFF, GA.—The perfect test firing of the world's largest rocket motor may prove to be a turning point in the dollar-starved large solid program.

Thiokol Chemical Corp. ignited its 156-in.-dia., 100-ft.-long solid motor at 12:15 p.m. EST, Feb 27, and some 64 secs. later more more than 800,000 lbs. of propellant had roared through the nozzle—reaching a peak thrust of 3.2 million lbs. Including all inert components, the motor cost less than $2.00 per lb.

The test was part of the large-solid demonstration program currently being handled by NASA's Lewis Research Center. The entire program to date had been a joint Air Force-NASA effort, with the Space Systems Div. of AF Systems Command controlling the military portion.

A. O. Tischler, director of chemical propulsion in NASA's Office of Advanced Research and Technology called the test . . . "an unmitigated, unqualified, unequivocal, unadulterated success."

- **On the nose**—Thiokol propulsion experts predicted a 70-sec. overall burn, and the actual time was 64 secs. The predicted functional burning time was 56.6 secs.; actual was 54.6 secs. The long tail-off period was primarily due to a lack of propellant slivers—a technique used to eliminate tail-off that was not deemed necessary in this test.

Chamber pressure was 737 psi against a predicted 742 psi. Peak thrust reached 3.2 million lbs. instead of the 3.210 predicted. Average predicted thrust was 3.02 million lbs., while the measured average hit 3.0 million lbs.

The proprietary insulation developed and applied by Thiokol to the inside of the huge motor case kept the outside wall at ambient temperatures through the test. The motor generated temperatures in the 5,800°F range. R. A. Tripp, Thiokol's director of program management, called the insulation a mastic and said it was applied like conventional caulking. The case will be cleaned and shipped to Lockheed Propulsion Co. for the AF 156-in. program.

The nozzle used in the test is exactly the same size planned for the 260-in. demonstration motors. Rohr fabricated it with woven tapes of carbon, graphite and silica impregnated with phenolic resins in those areas exposed to the gas flow. Erosion rates in past firings have varied from 0.003 in./sec. to 0.007 in./sec.

Main purpose of the Thiokol test was to check out the 260-in. motor nozzle. Details were not made available, but visual inspection by NASA and Thiokol officials after the firing confirmed the total absence of cracks, splits or signs of excessive or erratic erosion.

The throat area appeared smooth and circular and one expert said the nozzle looked good enough to fire again.

- **Nozzle design**—The inlet cone consisted of bias-cut, carbon-reinforced, phenolic-impregnated, tape material wrapped at a slight angle with respect to the center line of the nozzle. The throat section is composed of bias-cut, angle-to-centerline tape material, but with a graphite reinforcement.

The use of tape-wrapped graphite rather than graphite billets in this area minimizes the danger from thermal shock. The crack problem is also alleviated since, if formed, the crack will be oriented circumferentially due to the fiber strength versus cross-ply laminate strength. In general, such cracks, when oriented circumferentially, are no more detrimental than a delamination or planned ablative split line and will not affect performance.

- **Ignition test**—The 156-in.-dia. motor was ignited using a 114,000-lb.-thrust *Matador*-type motor fired downwards into the nozzle. After ignition, the *Matador* and its sled sailed free.

The huge booster motor was tied down in Thiokol's cast, cure and firing pit with the nozzle pointed up. The motor itself was below ground level and

House Group Expected to Vote Funds

IT APPEARS virtually certain the House Science and Astronautics Committee will vote for funding in NASA's Fiscal Year 1966 budget to continue the 260-in. solid booster program.

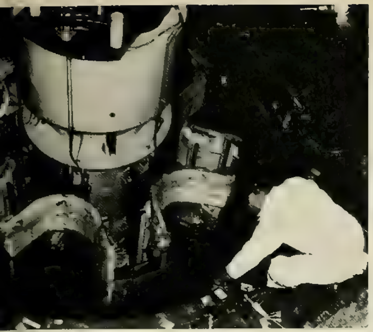
Most committee members feel that the big solid project, among the three programs cancelled by the Administration in the FY '66 budget, is the one that should be brought to a demonstration phase, since it already is so far down the road.

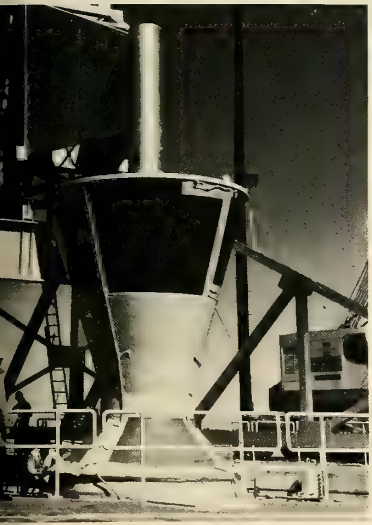
Although no committee members attended the recent firing of the 156-in. solid motor with the 260-in. motor nozzle at Thiokol's Brunswick, Ga., facility (see accompanying story), committee staff members were there and were greatly impressed.

The committee has also tried to find out why the program—so close to completion—was dropped from the budget. Repeated inquiries have been made of the Administration, but apparently no real answer has been forthcoming. The legislators feel that the program price is so low that the answer of "economy" is no justification.

It is estimated that $10-15 million would be needed to bring both contractors—Thiokol and Aerojet-General—to demonstration of the 260-in. motor. Best guess is that the committee may vote $12 million.

Although there has been some talk of funding the program with only one contractor, the general feeling seems to be that the disadvantages of cutting the program back outweight the cost factor





TOP LEFT: Star mandrel removed after propellant cure cycle, LEFT: Thiokol engineers ready huge nozzle mounted on 100-ft.-long motor. The cast-cure-firing pit is visible. ABOVE CENTER: Matador motor ignition system shown mounted on its sled and attached to rail assembly. ABOVE RIGHT: Close-up of the actual firing, in which more than 800,000 lbs. of propellant was consumed, reaching a peak thrust of 3.2 million lbs.

the nozzle component above ground.

Propellant processing, a 24-hr. 6-day operation, demonstrated the effectiveness of the automated batch mixing facility used (M/R, May 18, 1964, p. 21; Nov. 18, 1963, p. 26; Mar. 5, 1962, p. 36).

The motor itself was 100 ft. long and 156 in. in diameter, with a total weight of 900,000 lbs. The grain was cast with a star-shaped burning area and the massive segmented mandrel used was manufactured by Lockheed Industrial Products, Atlanta, Ga. While the motor case was built in segments, the grain was cast in one monolithic piece.

- **The argument**—Tripp told those present at the test that, while failure is often a spur to renewed effort, success frequently leads to complacency. Tripp said there is a recurring temptation to feel that "once you have acquired some new technology, you can put it on the shelf and leave it."

In an obvious reference to the Administration's slashing the 260-in. program from the budget, Tripp went on to point out that technology involves more than just documents—it depends on people. "If you do not have a program moving ahead, you are likely to find you have no program at all."

Tripp cited the reliability of solids, their predictability and control—and then went on into the cost picture. "Boeing Airplane Co. studies have shown that if solid-propellant technology being made available by this program had been available to the nation when the *Saturn I* development started, a considerable savings could have been realized," he said.

Specifically, he said, considering all costs of development through 80 launches, the study indicated that solids would have cost some $303 per pound of payload against the $606 for the liquid *Saturn IB*.

This amounts to a $16.5-million savings per launch—or a total savings of $1.3 billion over 80 launches.

Tripp also cited the payload gap between the *Saturn IB* and the *Saturn V*—and the payload void beyond *Saturn V*—as reasons for continued development of solids.

Tripp described a Thiokol all-solid vehicle called the Vulcan which would use 260-in. first and second stages and a 156-in. third stage for the *Saturn IB*-*Saturn V* payload gap. The concept envisions a nominal 100,000-lb. payload which can be decreased or increased through a building-block approach.

- **Supporting contractors**—Excelco Development Corp. supplied the maraging-steel, segmented motor case. The nozzle was fabricated by Rohr Corp. to Thiokol specifications, and the nozzle area was constructed of reinforced-plastic graphite and carbon materials developed by U.S. Polymeric Chemicals, Inc. Propellant ingredients were supplied by American Synthetic Rubber, Pacific Engineering and Englehardt Industries. U.S. Steel provided the 18%-nickel, maraging steel.

Both U.S. Polymeric and Fiberite Corp were cited by Thiokol for their advances in meeting "increased requirements in physical properties associated with the unusual fiber orientations in wide-width tapes." Both also contributed heavily by tailoring their resin systems to the special cure requirements demanded in the nozzle fabrication process.

The nozzle exterior surface was protected by Dyna-Therm Corp.'s X43-24 organic insulative/ablative coating. ■

Technical Countdown

ELECTRONICS

Apollo Fuel Cell Functions 1,000 Hours

The hydrogen/oxygen fuel cell designed and built by Pratt & Whitney Aircraft for the *Apollo* capsules (see p. 14) has been operated for more than 1,000 continuous hours. The unit is a complete fuel cell powerplant, containing all controls and auxiliary equipment for operation without external control. The test was carried out in a sealed vacuum chamber simulating the conditions of space. Scheduling of power demands were similar to those expected during the lunar voyage and maximum emergency power conditions were imposed at times. The 1,000-hour test is about twice as long as the planned lunar mission.

Military Comsat Details Disclosed

As part of the Initial Defense Communications Satellite Program, 24 spin-stabilized repeater satellites will be injected into near-synchronous equatorial orbits early next year, according to Maj. Gen. O. J. Ritland. The AF Systems Command deputy commander for space also disclosed that the satellites will have an orbital altitude of about 18,300 miles and will move across the sky at about 30 degrees per day. Each satellite will remain in view of a given station for up to five days. Since the satellites will carry no batteries, they will become inactive when they enter the Earth's shadow. A 2% down time for communication with any particular ground station thus will be experienced creating an outage of some significance, he said.

Ultra High Resolution Facsimile Proposed

Through the use of fiber-optic techniques, TV images could be produced with up to 50,000 horizontal lines, according to Fairchild Camera and Instrument Co.'s Dumont Laboratories. By scanning a target with a fiber optics shape converter, an image can be converted to modulated electrical energy and transmitted by radio. A second converter at the receiving end could then be used to unscramble the image intelligence and expose a photographic plate or the signals could be fed directly to a TV viewer. The firm has proposed such a system to provide detailed mapping of the lunar surface.

New Device Improves Laser "Q" Spoiling

A Kerr cell, capable of modulating CW and pulsed laser outputs in the infrared range, has been developed by Electro-Optical Instruments, Inc. The Xerox Corp. subsidiary claims that the unit "effectively doubles Kerr cell transmission and power-density characteristics at the 1.06- and 1.15-micron wavelengths common to neodymium and helium lasers, respectively." These wavelengths, developers pointed out, previously were absorbed by conventional Kerr cell fluids, but this now has been minimized by employing deuterated nitrobenzene as the working fluid. The new device is expected to further enhance high-power lasers for night rangefinding and communications by greatly increasing both switching speed and accuracy.

Big Lenses Support Nuclear Studies

Giant lenses, measuring one meter in diameter and weighing over 350 lbs.—the largest ever ground by Carl Zeiss, Inc.—are being used by European researchers to photograph the paths of high-energy particles. Employed with the hydrogen bubble chamber of CERN at Geneva, Switzerland, six lenses are paired in front of three high-power flash lamps to concentrate and direct light into the chamber.

ASTRONAUTICS

Inverted Gun to Simulate Re-entry

Projectiles traveling at speeds upward of 35,000 mph, considerably higher than re-entry from the planets, are promised by scientists from the University of Toronto. They hope to generate such speeds by using lens-shaped charges of explosive whose energy is directed into a small .22 calibre rifle barrel. In turn, specially tailored bullets within the gun are discharged with "re-entry" speed into a massive steel tube, 2 ft. in dia. and 30 ft. long, pumped down to 10^{-12} atmospheres.

MATERIALS

Pyrolitic-Impregnation Upgrades Graphite

Vapor-deposited pyrolitic graphite substantially improves the physical and chemical resistance properties of commercially available graphite and carbon. The pyrolitic-graphite-impregnated graphite increases in bulk density, thermal conductivity, thermal diffusivity, and flexural, tensile and compressive strengths. The process was developed at the General Electric Metallurgical Products Dept., Detroit, Mich. The impregnation increases the uses of bulk graphite forms and can be stopped at any surface layer thickness desired. In one instance, an experimental grade of graphite with an original density of 1.40 gm/cm^2 had its compressive strength raised from 2,000 psi to 7,300 psi after processing with pyrolitic graphite.

Bethlehem Rolls Titanium Sandwich

Diffusion-bonded titanium sandwich panels have been successfully rolled at Bethlehem Steel Corp.'s Sparrow Point, Md., Plant. The close-tolerance, square-edged flat composite panels measured 0.5 in. x 48 in. x 120 in. The plate composite, when separated from its carbon steel cover plates and filler bars, will yield a 0.25 x 36 x 72-in. truss core sandwich of titanium 6A1-4V alloy having 0.016-in.-thick face sheets and truss elements. The roll-welding process was developed by Dr. Robert I. Jaffee of Battelle Memorial Institute. The rolled sandwich plate will be shipped to both Battelle and Douglas Aircraft Co.'s Missile and Space Systems Div. for further processing into structural shapes.

Fast Curing Epoxy System Developed

A series of two-part epoxy resin systems developed by Adhesive Engineering, 1411 Industrial Road, San Carlos, Calif. will cure in minutes at room temperatures when applied as thin films. The firm's spokesmen claim the fast cure rates are a breakthrough and should increase the use of epoxy adhesives and coatings. The resins can even cure as low as 0°F. Most of the epoxies developed from the system will cure in 30 hours at 0° F and from 30 to 60 minutes at room temperature. Some members of the family cure at much shorter times. Tensile strengths run from 2,000 to 10,000 psi with 10% to 60% elongation with excellent resistance properties. Surface preparation and application procedures are the same as for other epoxies.

ASTROLOG

Current Status of U.S. Missile and Space Programs

satellites and spacecraft

ADVANCED ORBITING SOLAR OBSERVATORY (NASA)
Republic, prime. DESCRIPTION: 1,250-lb. spacecraft to make detailed measurements of Sun's solar radiation; greater pointing accuracy (5 arc sec) than OSO; launch vehicle, THRUST AUGMENTED THOR-AGENA. STATUS: Development funding in FY '66 budget; two spacecraft to be launched in 1969, two in 1971.

APPLICATIONS TECHNOLOGY SATELLITE (NASA)
Hughes, prime; GE, gradient stabilization. DESCRIPTION: Five-satellite program to test communication and meteorological equipment at medium and synchronous orbit; test bed for gravity gradient communications and meteorological experiments; weight, 780 lbs.; launch vehicle, ATLAS-AGENA. STATUS: Development; first flight scheduled for late 1966.

APOLLO (NASA)
North American, Command & Service modules, systems integration; Grumman, Lunar Excursion Module (LEM); MIT, guidance development; AC Spark Plug, guidance prime; Collins Radio, telecommunications; Honeywell, stabilization & control; AiResearch, environmental control; Northrop-Ventura, parachute recovery; Lockheed Propulsion Co., escape tower rocket; Marquardt, reaction controls; IBM, realtime computer complex; Westinghouse, power conversion equipment. Lunar Excursion Module, prime, Grumman; descent engine, TRW Space Technology Laboratories; ascent engine, Bell Aerosystems; environmental control, Hamilton Standard; reaction control thruster, Marquardt; guidance, MIT; radar & communications instruments, RCA; TMC, telemetry, Radiation Inc.; fuel cell, Pratt & Whitney; external visual display, Forand Optical; GE, acceptance checkout reliability. DESCRIPTION: Three-man spacecraft for Earth-orbital, lunar-orbital and lunar-landing missions. Boosters: SATURN I and SATURN IB for Earth orbits; SATURN V for lunar rendezvous and landing missions; 3-modular spacecraft: Command Module weight, 5-1/2 tons; Service Module, 25 tons; Lunar Excursion Module, 15 tons; total weight, 95,000 lbs. STATUS: First of a series of unmanned orbital tests began with a boilerplate model launch on SA-7, Sept. 18, 1964; LITTLE JOE II unmanned abort test successful, Dec. 8, 1964; lunar orbits scheduled 1968; lunar landing by 1970; first manned orbital flight due last half of 1966.

ASSET (Air Force)
McDonnell Aircraft Corp., prime; Honeywell, gyros; Bell Labs, guidance. DESCRIPTION: Aerothermodynamic/elastic Structural Systems Environmental Tests for various materials combinations during re-entry; delta-shaped re-entry vehicle; two versions planned weighing 1,100 lbs. (4 vehicles) and 1,200 lbs. (2); length, 68.7 in.; span, 58.9 in. STATUS: Development. One AMR shot in September, 1963, successful although vehicle not recovered; third vehicle successfully launched and recovered, July 22, 1964; fourth launched Oct. 28, 1964; fifth successfully launched Dec. 8, 1964; sixth successfully launched Feb. 23, 1965, not recovered; end of program, unless recovered ASV-3 vehicle is re-flown. (See START).

BIOS (NASA)
GE, prime. DESCRIPTION: 1,000-lb. satellites to test effects of space environment on plants, animals (primates) and other biological specimens; launch vehicle, THRUST-AUGMENTED DELTA. STATUS: Six flight models to be built; first flight in December, 1965; others to follow at three-month intervals; first experiments selected in February, 1965.

COMSAT CORP. SATELLITE PROGRAM
Studies being performed by Hughes, TRW with ITT, and AT&T and RCA as joint contractors. STUDIES: AT&T/RCA, 18 satellites, medium-altitude random orbit; STL/ITT, 12 satellites, medium-altitude, controlled orbit using gravity-gradient stabilization; Hughes 2nd-generation synchronous orbit system. STATUS: First satellites to be in orbit by mid-1966, with entire system operational by mid-1967.

DISCOVERER (Air Force Program 622A)
Lockheed, prime; GE, re-entry vehicle. DESCRIPTION: THOR-AGENA and ATLAS-AGENA launchings of stabilized satellites; main purpose is to test techniques and components for military space systems. STATUS: All data on program classified as part of DOD information policy; however, indications are that program has been cut back or ended as more economical vehicles have come into use.

EARLY BIRD (ComSat Corp.)
Hughes, prime. DESCRIPTION: Experimental modified syncom to be placed in 22,300-mi. stationary orbit and provide 240 two-way telephone channels between U.S. and Europe or simultaneous transmission of 22 or more telegraph messages; booster, THRUST-AUGMENTED DELTA. STATUS: Development; contract calls for delivery of first satellite by April, 1965; launch scheduled for mid-1965.

ECHO (NASA)
Langley Research Center, prime. DESCRIPTION: ECHO I, 135-ft. inflatable sphere in 700- to 805-mi. orbit; passive communication satellite; booster, THOR for ballistic tests; THOR-AGENA for orbital. STATUS: Program complete; ECHO I in orbit since Aug. 12, 1960; two ballistic shots in 1962 unsuccessful; ECHO II launched from Vandenberg Jan. 27, 1964; U.S.-USSR conducting series of cooperative experiments using ECHO.

GEMINI (NASA)
McDonnell, prime; Rocketdyne, spacecraft propulsion; General Electric, fuel cell; IBM, guidance system integration and computer; Honeywell, guidance; Westinghouse, rendezvous radar; AiResearch, environment. DESCRIPTION: Bigger and heavier MERCURY-type capsule to carry two men for up to two weeks; TITAN II to be used as booster; ATLAS-launched AGENA will be used for rendezvous missions; 15 spacecraft will be produced. STATUS: Development; 12 flights planned; will be used to determine feasibility of rendezvous for lunar mission and long-duration manned flight; first unmanned flight, April, 1964, successful; second unmanned orbital flight, January, 1965, successful; first manned flight due in March-April; three other flights scheduled for 1965; manned and rendezvous flights, 1966-67; AF participating in program, and will modify GEMINI capsules for MANNED ORBITING LABORATORY.

GEOS (NASA)
Applied Physics Laboratory, prime. DESCRIPTION: 350-lb. geodetic satellite (similar to ANNA) to carry flashing-light beacons, electronic beacons and optical and radar reflectors; launch vehicle, THOR-ABLE-STAR; 700-900-mi. orbit at a 59-degree inclination. STATUS: First flight planned in third quarter 1965. PAGEOS passive satellite developed by Langley Research Center will also be launched in the first half of 1966.

HYPERSONIC RESEARCH VEHICLE (AF, NASA)
No contractors announced. DESCRIPTION: Manned-hypersonic

spacecraft capable of Earth-to-orbit-and-return; turbofan, Mach 0-3; ramjet, Mach 3-8 or 10 (oxygen collected and liquefied during this cycle); Mach 8-10 orbital speeds, LH_2-LOX rocket. STATUS: Joint NASA-AF research program approved; NASA funding $5 million in FY '66; AF has advanced technology program in six pertinent areas (mostly engine developments) in FY '65. Two firms to be selected for conceptual and preliminary design of a research engine; engine flight test planned for early 1968.

ICBM ALARM (Formerly MIDAS) (Air Force Program 239A)

Lockheed, prime; Aerojet, IR detector system. DESCRIPTION: Early-warning random-orbit satellite; detect ICBM launchings by IR; two flights conducted in 1963 detected solid and liquid missile launches; satellites are launched piggy-back on various AF boosters. STATUS: Development; no decision on deployment; reportedly competing with over-the-horizon radar.

INTERPLANETARY MONITORING PLATFORM (NASA)

Goddard Space Flight Center, prime; Martin Co. developing nuclear power unit. DESCRIPTION: 131-181-lb. satellite launched into cis-lunar-space orbit with an apogee of more than 100,000 mi.; will measure radiation and solar flare hazards in advance of Project APOLLO; launched by DELTA and THRUST-AUGMENTED DELTA boosters from AMR. STATUS: IMP-I launched in December, 1963; IMP-II launched Oct. 3; five more satellites are planned, two to be placed in lunar orbit; later flights will use a nuclear power unit as replacement for solar cells; Designation, IMP-A is EXPLORER XVIII; IMP-B is EXPLORER XXI.

ISIS (Canada, U.S.)

Canadian Defense Research Board, satellite; NASA, launch vehicle. DESCRIPTION: Three-satellite follow-on program to ALOUETTE to continue ionospheric studies. STATUS: Design of ISIS A began in 1964 with launch planned in 1967; B and C to be launched in 1968, 1969; launch vehicle, THOR-AGENA.

LUNAR LOGISTICS SYSTEM (NASA)

Studies have been conducted by Grumman, TRW/STL and Northrop. DESCRIPTION: Spacecraft to carry support payloads to the Moon. Two designs under study—LEM truck with 7,000-lb. payload and logistics spacecraft with 25,000 to 30,000-lb. payload; booster: SATURN V. STATUS: Program definition of the LEM truck planned in FY '66; program would cost about $1 billion; first step will be to extend lunar stay-time up to two weeks.

LUNAR ORBITER PHOTO CRAFT (NASA)

Boeing, prime; RCA, power and communications; Eastman Kodak, cameras; Marquardt, maneuvering engine. DESCRIPTION: 800-lb. spacecraft launched by ATLAS-AGENA will orbit Moon taking pictures of lunar surface; radioactive and geodetic measurements will also be taken. STATUS: Five flights scheduled beginning in mid-1966.

MANNED ORBITING LABORATORY (Air Force)

Aerospace Corp., systems engineering & technical direction; study contracts awarded to Douglas, GE and Martin on the ORBITING SPACE STATION (OSS); also contracts for studies of selected subsystems. DESCRIPTION: Two-man spacecraft to establish military usefulness of man in space; booster, TITAN III-C; GEMINI-B capsule atop 10-ft.-dia., 14-ft.-long canister lab; total weight about 18,000 lbs.; orbit below 350 mi.; flights of 30 days in shirt-sleeve environment planned. STATUS: Sixty-day preliminary design studies totaling $400,000 each were awarded Mar. 1 to four competing contractors, Boeing, Douglas, GE and Lockheed. $150 million in FY '66 funding requested; RFP's for program definition expected to be issued by mid-1965; unmanned GEMINI launch early 1966; unmanned canister launch late 1967, manned, first half 1968; rendezvous capability possible later. APOLLO hardware proposals being considered along with GEMINI in broadened MOL concept.

MARINER (NASA)

Jet Propulsion Laboratory, prime. DESCRIPTION: 570-lb. unmanned spacecraft for early interplanetary missions to vicinity of Mars and Venus; boosted by ATLAS-AGENA. STATUS: First scheduled Venus fly-by, August, 1962, unsuccessful after booster failure; second passed within 21,594 mi. of Venus, Dec. 14; two Mars fly-by spacecraft launched in November, 1964; first on Nov. 5 failed due to shroud malfunction; second on Nov. 28 successful, expected to pass Mars July 14; because of press of maintaining APOLLO schedules, NASA has dropped plans for 1966 & 1969 Mars shots; agency will go directly to VOYAGER, a 7,000-9,000-lb. spacecraft for missions in 1970's, with a test flight in 1969.

MILITARY COMMUNICATIONS SATELLITE (Prog. 369) (AF, DCA, Army)

Aerospace Corp., systems engineering & technical direction; Philco, prime. DESCRIPTION: Multiple-launch, random, active repeater comsat; 24 satellites launched in groups of 8 satellites in 18,300-n.mi. polar orbits; weight about 100 lbs.; TITAN III-C booster. STATUS: Full-scale development as an "interim" system which is to be in operation in 1966. DCA has requested ideas from industry on a longer-lived Advanced Communication Satellite system; study contracts expected to be awarded by April 15, with FY 1968 operational status planned.

NATIONAL ORBITING SPACE STATION (NASA, AF)

Many studies awarded. DESCRIPTION: Manned space station with orbital lifetime of one to five years for testing components and techniques in the space environment; weight ranges under study vary from 15,000-20,000 up to 200,000 lbs. STATUS: Decision not expected for one to four years; APOLLO-X, AF MANNED ORBITING LABORATORY, MANNED ORBITING RESEARCH LABORATORY and LARGE ORBITING RESEARCH LABORATORY being considered; program definition of APOLLO-X expected in FY '66; longer-life stations delayed until 1970's.

NIMBUS (NASA)

Goddard Space Flight Center, prime; GE, integration and testing; RCA, videcon cameras. DESCRIPTION: 900-1,100-lb. second-generation weather satellite; Earth-stabilized polar orbiting; TV cameras and IR scanners in payload; THOR-AGENA B booster. STATUS: First launching successful August 28; picture & IR quality good in spite of satellite's elliptical orbit; satellite quit transmitting Sept. 23; second scheduled in 1966, third in 1967 and fourth in 1968-69.

NUCLEAR DETECTION SATELLITES (Formerly Vela) (ARPA)

TRW Space Technology Laboratories, prime; Los Alamos Scientific Lab/Aerospace Corp., payload. DESCRIPTION: 20-sided, 485-lb. satellite for detection of nuclear explosions in space; 50,000-mi. orbit; booster, ATLAS-AGENA; launched in pairs. STATUS: First pair successfully launched in October, 1963; second pair successfully launched July 17, 1964; three pairs remain.

OAO (NASA)

Grumman, prime; Westinghouse, ground station, components; GE, stabilization and control; Kollsman, star trackers; IBM, data processor and storage; Hughes and Avco, communications equipment. DESCRIPTION: 3,600-lb. orbiting astronomical satellite to study ultraviolet spectrum from approximately 1,200 Å to 4,000 Å; four major experiments selected; one piggyback; booster, ATLAS-AGENA D. STATUS: Three flights beginning in late 1965.

OGO (NASA)

TRW Space Technology Laboratories, prime; DESCRIPTION: 1,000-lb. satellite with instruments for geophysical measurements; polar (POGO) and eccentric (EGO) shots planned; can carry more than 20 experiments; ATLAS-AGENA B, THRUST-AUGMENTED THOR boosters. STATUS: First launch on Sept. 4 partially successful; 16 of 20 experiments working; five other launches planned, with next flight scheduled for second half of 1965.

OSO (NASA)

Ball Brothers, prime. DESCRIPTION: OSO 1,458-lb. orbiting solar observatory; OSO II, 535-lbs.; DELTA booster; S-16 early version; S-17 and S-57 advanced versions. STATUS: First flight Mar. 7, 1962, highly successful; first flight for S-17 planned for second quarter 1964 delayed until 1965; six more flights planned.

PEGASUS (NASA)

Fairchild Hiller, prime. DESCRIPTION: 3,400-lb. meteoroid-detection satellite employing two 50 x 15 ft. extendable detector wings; Earth orbit 300 to 800 mi.; booster, SATURN I. STATUS: Development; will measure size, energy and frequency of meteoroids to evaluate hazards of impact with manned spacecraft; first launch successful in February, 1965; formerly known as METEOROID DETECTION SATELLITE; two more satellites will be launched as part of SATURN I development program. CISLUNAR PEGASUS may be launched in 1968-69.

PIONEER (NASA)

TRW Space Technology Laboratories. DESCRIPTION: 130-lb. spin-stabilized solar probe; augmented DELTA launch vehicle; cylindrical; covered with 10,000 solar cells; four outrigger booms for stabilization; five experiments, 60 to 90-million-mi. communication capability. STATUS: Seven launches in program; mid-1965 launch schedule set; orbits range from 0.8 to 1.2 au for 6-mo. lifetime; EXTENDED PIONEER under study.

PROJECT SCANNER (NASA)

Honeywell, fabrication and integration; Baird-Atomic, star-mapper telescope; Santa Barbara Research Center, dual radiometers. DESCRIPTION: Unmanned scientific satellite to measure natural radiation gradients of Earth's horizon to determine utility of spacecraft horizon sensors. STATUS: Flights to begin in 1965.

RADIO ASTRONOMY EXPLORER (NASA)

Goddard, prime for first two spacecraft with industry to build remaining four. DESCRIPTION: 270-lb. satellite which will have four 750-ft. extendable antennas to pinpoint radio emissions in space. STATUS: Hardware funding approved in FY '65 & '66 budgets, with first launch by a THRUST-AUGMENTED DELTA in 1967.

RANGER (NASA)

JPL, prime; Hercules, retro-rocket; Northrop, support contractor; RCA, TV system. DESCRIPTION: Before impact, TV cameras take pictures of lunar surface; ATLAS-AGENA B booster. STATUS: RANGER VI launch Jan. 30, 1964, TV system failed; RANGER VII launched July 28, 1964, and impacted Moon after transmitting 4,316 pictures back to Earth; RANGER VIII launched Feb. 17, 1965, impacted Moon Feb. 20, after transmitting more than 7,000 pictures; RANGER IX, scheduled for mid-March, will close program.

RELAY (NASA)

TRW Space Technology Laboratories, project coordination and systems planning; RCA, prime. DESCRIPTION: 172-lb. spin-stabilized wideband 800 to 4,600-mi.-orbit active repeater experimental communications satellite; DELTA booster. STATUS: Britain, France, Brazil and Germany building ground stations; first launch, Dec. 13, 1962; RELAY II launched Jan. 21, 1964; program completed.

SAMOS (Air Force Program 720A)

Lockheed, prime; photo intelligence equipment, Eastman Kodak; capsules, GE; parachute and guidance recovery equipment, Avco and Northrop Ventura. DESCRIPTION: Reconnaissance satellite; formerly SENTRY; R&D model weighs 4,100 lbs. with E-5 capsule (3,000 lbs. with E-6); ATLAS-AGENA booster; 100-300-mi. circular polar orbit. STATUS: Operational; advanced SAMOS under development; FERRET version used for electronic intelligence and communications eavesdropping.

SATAR (Air Force)

General Dynamics, prime. DESCRIPTION: 300-lb. scientific satellite pod mounted on side of ATLAS booster; length, 55 in.; diameter 27 in.; 200-lb. payload; orbits vary from 500 to 2,000 n. mi.; as re-entry vehicle, gains speeds up to 30,000 fps; guidance, strap-down system with three orthogonally mounted gyros; unstabilized when in orbit. STATUS: Development; seven vehicles being built under present contract; pods of SATAR type have been flown on 44 missions.

SATELLITE INSPECTOR (Air Force PROGRAM 706)

No contractors announced. DESCRIPTION: Satellite inspection system consisting of a spacecraft capable of co-orbital inspection of non-cooperative satellites. STATUS: Re-oriented from unmanned vehicle to manned satellite using GEMINI; Conceptual preliminary design studies under way; early GEMINI flights expected to provide important inputs; $2 million in FY '65 budget.

SECOR (Army)

ITT Labs, prime; Cubic Corp., transponder. DESCRIPTION: 40-lb. geodetic satellite; rectilinear, measuring 9 x 11 x 14 in.; can be carried piggyback on a variety of boosters; frequency, 162-324 mc for geodetic measurements; 54-216 mc for refraction studies. STATUS: Operational; third launch took place early in 1964 on AF secret satellite; an expanded program at altitudes of 1,800 mi. is being considered.

SERT (NASA)

RCA, prime. DESCRIPTION: Spinning ballistic test vehicle carrying two electric-propulsion engines for environmental tests. STATUS: First flight July 20 from Wallops Island, Va., carried a Lewis electron bombardment engine and a Hughes contact ionization engine; the Lewis engine worked well while Hughes engine produced no thrust; follow-on flights cancelled since SERT I proved neutralization of an ion beam in space; SERT III now under study.

START (Air Force)

Award in only one of an expected 10-14 areas has been announced; Martin Co. for work on a vehicle related to the in-house SLV-5 Aerospace Corp., general systems engineering and technical direction. DESCRIPTION: An experimental program, much broader than ASSET, to explore the materials, structures, flight regimes and other areas related to glide atmospheric entry. STATUS: Program package is still being assembled.

SURVEYOR (NASA)

Hughes, prime; Martin, SNAP device. DESCRIPTION: 2,150-lb. spacecraft for soft-landing 100-300 lbs. of instruments on Moon; nine 2,500-lb. spacecraft are also planned; ATLAS-CENTAUR booster; SNAP nuclear generator optional. STATUS: First Moon flights early 1966; five soft-landing vehicles planned in Block I series.

SYNCOM (NASA)

Hughes, prime. DESCRIPTION: 24-hr.-orbit instantaneous narrow-band, active-repeater communications satellite; 28 in. in dia. and weighs about 63 lbs.; DELTA booster; capable of accommodating one full duplex radio telephone channel. STATUS: First launch failed, Feb. 14, 1963; satellite believed to be in orbit but contact lost; SYNCOM II launched July 26, 1963, completely successful; third launch Aug. 19 successful; satellite, positioned in stationary orbit over Pacific, relayed 1964 Olympic Games to U.S. from Japan; program now complete. DOD has taken over satellites for military traffic.

SMS (Synchronous Meteorological Satellite) (NASA)

Republic, RCA Astro-Electronics, Hughes, study contracts. DESCRIPTION: 24-hr. weather satellite, Earth-stabilized; TV cameras with variable focus; may use SNAP-50 for power; booster may be ATLAS-AGENA or -CENTAUR. STATUS: Studies to continue; development funds not included in FY '66 budget; ATS and TIROS expected to provide major inputs to the program.

TELSTAR (AT&T, NASA)

Bell Telephone Laboratories, management for AT&T. DESCRIPTION: 170-lb. active repeater experimental industry communication satellite; DELTA booster. STATUS: Development; first launch July 10, 1962, highly successful; second launch May 7, 1963, also successful; program now complete.

TIROS NASA, Weather Bureau

RCA, prime. DESCRIPTION: 285-lb. meteorological satellite; TV pictures of cloud cover; IR sensors to gather heat balance data; one TIROS to be tested for effectiveness in highly elliptical orbit (300-3,000 mi.) STATUS: R&D; nine satellites launched; all successful; five more launches planned with TIROS wheel configuration (Earth stabilized) to serve as an interim National Operational System.

TRANSIT (NAVY)

Applied Physics Laboratory, prime; Martin, SNAP device; Westinghouse, shipboard satellite signal receivers. DESCRIPTION: Navigational satellite; R&D model over 250 lbs.; operational, 50 to 100 lbs.; operational system; four satellites in random, near-circular 600-mi. orbits; SNAP nuclear generator; ABLESTAR, SCOUT booster. STATUS: Four-satellite system operational since July, 1964; system established for use by POLARIS subs and surface ships; two nuclear-powered (SNAP-9A) satellites launched in 1963; NASA exploring feasibility of commercial system.

TRS (Air Force)

TRW/STL. DESCRIPTION: 3-lb. scientific satellite to measure radiation; four-sided, measuring 9 in. on a side. STATUS: Operational; first launched piggyback on DOD payload Oct. 17, 1963.

VOYAGER (NASA)

Seven firms competing for phase I study contracts. DESCRIPTION: Unmanned 7,000-10,000-lb. MARINER follow-on spacecraft bus/lander to orbit Mars and eject a capsule to the surface. STATUS: Development expected to begin in early 1966; program definition funded in FY '66; launches in 1971-73 period; spacecraft to be launched by SATURN IB/CENTAUR, and will be used to explore other planets through 1970's.

X-15 (NASA, AF, NAVY)

North American, prime; Thiokol, propulsion; Sperry Gyroscope, inertial flight data system; Honeywell, adaptive flight control electronics. DESCRIPTION: Manned rocket plane capable of 4,000-mph-plus flight at edge of space; single rocket engine develops 57,000 lbs. thrust. STATUS: Powered flights in progress; unofficial records set—altitude 354,200 ft. and speed 4,104 mph; hypersonic propulsion research program should run through 1968; more than 100 flights have been made; ramjet (X-15A2) flights scheduled for 1968.

space vehicles

ABLESTAR (Air Force)

Space-General, prime; Aerojet, propulsion; Space-General/Bell Telephone, guidance. DESCRIPTION: 2,000-lb. upper stage; 9.5 ft. long; 55 in. dia.; radio command guidance; propellants, UDMH/IRFNA; restart capability. STATUS: Used in TRANSIT and other military programs; THOR booster.

ATHENA (Air Force)

Atlantic Research, prime; Honeywell, guidance. DESCRIPTION: 17,500-lb. four-stage re-entry vehicle, attains apogees from 600,000 to 1,000,000 ft.; last two stages drive vehicle and payload Earthward at near-ICBM velocities; major diameter, 32 in.; velocity package diameter, 28 in.; length, 51 ft. First-stage engine, Castor XM 33 (Thiokol); second stage, either X261 (Thiokol) or X259 (Naval Propellant Plant); third stage, 30KS 8000 (Aerojet); fourth stage, Ranger Retro BE3, Hercules. STATUS: Engaged in sub-scale testing of advanced re-entry concepts; 77 launches scheduled; 12 have been flown from Green River, Utah, site into White Sands Missile Range, N.M.; last flight Feb. 15.

ATLAS-AGENA D (Air Force)

General Dynamics/Aeronautics, (ATLAS); Lockheed (AGENA); TRW/STL, AGENA B; Honeywell, inertial reference. DESCRIPTION: 275,000-lb. booster; payload capability, 5,000 lbs., in 345-mi. orbit, 750 lbs. to escape, length, 102 ft.; base diameter, 10 ft.; liquid propulsion; modified Atlas D with 360,000-lb. thrust; Agena B with 15,000-lb. thrust; restart capability. STATUS: Operational; used in RANGER, DISCOVERER, MILITARY COMSAT, MARINER, LUNAR ORBITER, OAO, SAMOS and other programs.

AGENA D (Air Force)

Lockheed, prime; Honeywell, guidance; Bell, propulsion. DESCRIPTION: 1,700-lb. upper stage; 25 ft. long; 5 ft. dia.; all-inertial guidance; propellants, UDMH/IRFNA; multiple re-start capability; ATLAS, THOR and THOR-augmented boosters. STATUS: Used in DISCOVERER, SAMOS and other military programs as well as a variety of NASA programs; e.g., MARINER, RANGER, OAO and OGO.

CENTAUR (NASA)

Lewis, program management; General Dynamics/Astronautics, prime; Pratt & Whitney, propulsion; Honeywell, guidance. DESCRIPTION: High-energy upper stage using a pair of RL-10 LOX/liquid hydrogen engines; 30,000 lbs. total thrust; 30 ft. long; 10 ft dia.; ATLAS D booster; capable of orbiting 8,500 lbs.; 2,300 lbs. to escape; 1,300 lbs. on planetary flights. STATUS: Development; first flight failed; second launch Nov. 27, 1963, successful; third, June 20, 1964, partially successful; fourth flight successful launched Dec. 11; fifth flight Mar. 2 failed when ATLAS-CENTAUR exploded on pad; three more flights set for 1965; vehicle to become operational in 1965.

DELTA (NASA)

Douglas, prime; Bell Telephone Labs, guidance; Rocketdyne/Aerojet/Allegany Ballistics Laboratory, propulsion. DESCRIPTION: Successor to THOR-ABLE; upper stage guidance; three-stage vehicle; 800-lb. payload capability in 100-mi. orbit; THRUST-AUGMENTED DELTA payload capability 1,500 plus lbs. in 100-mi. orbit; THOR missile comprises first stage. STATUS: launch vehicle for TIROS, EXPLORER, OSO, BIOS, ECHO; TAD used for SYNCOM & PIONEER; 26 previously on order augmented by AF order for 21 more for NASA; THRUST-AUGMENTED DELTA with three solid motor strap-ons also being used.

LITTLE JOE II (NASA)

General Dynamics/Convair, prime. DESCRIPTION: Solid-propelled vehicle with 800,000-lb. thrust; launch vehicles for APOLLO suborbital flights. STATUS: Three launches Aug. 28, 1963, May 13, 1964, Dec. 8, 1964, successful; six vehicles ordered thus far.

POST-SATURN V LAUNCH VEHICLE (formerly NOVA) (NASA)

Under study. DESCRIPTION: Capability of NOVA under study; no firm concept but will be significant improvement over C-5 (20-30 million-lb. first-stage thrust large solid motors, and nuclear upper stage under consideration). STATUS: Study to determine characteristics; operational target date post-1970.

PROJECT FIRE (NASA)

Republic, re-entry package; Ling-Temco-Vought, velocity package; General Dynamics/Astronautics, launch vehicle and systems integration. DESCRIPTION: Re-entry probe to measure environmental heating at lunar return speeds (25,000 mph); launch vehicle, ATLAS D plus Antares II A-5 (re-entry booster). STATUS: R&D; first flight April, 1964, successful; second flight scheduled for mid-1965.

ROVER (NASA, AEC)

Los Alamos Scientific Labs, ROVER prime; Aerojet, NERVA prime; Westinghouse, propulsion. DESCRIPTION: First nuclear rocket; tests of Kiwi, prototype of NERVA engine, under way. STATUS: Kiwi tests completed this year; NERVA tests highly successful; full systems tests of engine now set for fall, 1965—12 months ahead of schedule; development of Phoebus reactor initiated; no flight test program funded at present.

SATURN I (NASA)

Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler Corp.; S-IV, Douglas. DESCRIPTION: Two-stage vehicle for early boilerplate tests of APOLLO and PEGASUS; first stage: eight Rocketdyne H-1 engines; second stage: six Pratt & Whitney RL-10-A3 engines; 22,500 lbs. into 345-mi. orbit. STATUS: Four flight tests of first stage successful; all flights with inert upper stage; first flight with live upper stage successfully launched Jan. 27, putting 37,700 lbs. in low Earth orbit; SA-6 May 28, 1964 and SA-7 Sept. 18, 1964, also successful; SA-9 on Feb. 16 put PEGASUS Satellite into orbit; two more R&D flights planned to complete development effort.

SATURN IB (NASA)

Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler; S-IVB stage, Douglas. DESCRIPTION: S-1, eight H-1 engines; S-IVB, one J-2 engine; payload capability, 35,000 lbs. in 105-mi. orbit. STATUS: Development; first flight in 1966; boost APOLLO spacecraft boilerplate models, including lunar landing vehicle; first manned flight in APOLLO program set for late 1966; advanced version able to orbit 30 tons under consideration. Booster for VOYAGER with CENTAUR upper stage.

SATURN V (ADVANCED SATURN) (NASA)

Systems engineering, assembly and guidance, Marshall Space Flight Center; S-IC stage, Boeing; S-11, North American; S-IVB, Douglas; F-1 engine, North American; J-2, North American. DESCRIPTION: S-IC, five F-1 engines; S-II, five J-2 engines; S-IVB, J2 engine; 140-ton payload in 105-mi. orbit; 95,000 lbs. to escape velocity; 30 tons for planetary missions. STATUS: R&D; first flight scheduled for 1967; prime booster for APOLLO missions; will be used to boost orbiting space station.

SCOUT (NASA)

LTV Aerospace Corp., prime; Honeywell, guidance; Aerojet/Thiokol/Allegany Ballistic Laboratory, propulsion. DESCRIPTION: Solid propulsion four-stage satellite launcher; 72 ft. long; 3.3 ft. dia.; 240-lb. payload in 345-mi. orbit; 80 lbs. to escape. STATUS: Operational; used by NASA for EXPLORER and other small payloads; also procured by NASA for Air Force as BLUE SCOUT; NASA has ordered 23 more boosters.

THOR-ABLE STAR (Air Force)

Douglas, prime; Bell Telephone labs, guidance; Rocketdyne, first-stage propulsion; Space-General, second; DESCRIPTION: Two-stage vehicle with 181,900 lbs. total thrust; performance, 900 lbs. in 100-n.-mi. orbit; length, 55.9 ft., diameter, 8 ft., weight, 118,200 lbs., height, 79 ft.; guidance, radio command; STATUS: Operational; used in TRANSIT, GEOS and other military programs.

THOR-AGENA D (Air Force and NASA)

No prime; Douglas, THOR frame; Lockheed, AGENA D; Rocketdyne, propulsion. DESCRIPTION: Liquid-propulsion vehicle to put 1,600-lb. payload in 300-mi. orbit; length, 76 ft.; diameter, 8 ft.; launch weight, 123,000 lbs.; 172,000 lbs. thrust; THOR, radio guidance, AGENA, all-inertial. STATUS: Operational; used in AF space program, TELSTAR, Topside Sounder and other NASA programs; NASA has 11 launches scheduled.

THRUST-AUGMENTED DELTA (NASA)

Douglas, prime; Thiokol, solid propulsion. DESCRIPTION: DELTA launch vehicle with three strap-on solids; performance, 1,000 lbs. to Earth orbit; 150 lbs. to escape; propulsion, three XM-33 solid motors producing 55,000 lbs. thrust each. STATUS: Development; to be used for BIOSATELLITE, PIONEER, SYNCOM, TIROS, COMSAT programs; initial flight Aug. 19, 1964, successful.

THRUST-AUGMENTED THOR (Air Force/NASA)

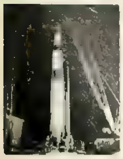
No prime; Rocketdyne and Thiokol, propulsion. DESCRIPTION: THOR-AGENA with 3 strap-on solids; THOR liquid propulsion, 172,000 lbs. of thrust; each strap-on, 55,000 lbs. thrust; performance, 2,500 lbs. in 100-n.mi. orbit. STATUS: Operational; used for NIMBUS, POGO and other payloads too heavy for THOR, but not heavy enough for ATLAS.

TITAN II (GLV) (NASA)

Aerospace Corp., systems engineering & technical direction; Martin, prime. DESCRIPTION: Manned space booster; Essentially Titan II with addition of redundant electrical power and flight control systems, malfunction detection system and radio command guidance. STATUS: Development; GT-2 (unmanned version) launched Jan. 19; GT-3 to be launched in April.

TITAN III (Air Force Program 624A)

Aerospace Corp., systems engineering & technical direction; Martin, systems integration; United Technology, large solid boosters; Martin, TITAN II portion; Aerojet-General, liquid engines (Transtage); Martin, standardized upper stage; AC Spark Plug, guidance. DESCRIPTION: Quick-reaction vehicle for military space missions; will be used to boost MOL/GEMINI B; Zero stage, two 120-in. solid motors; first and second stages, TITAN II (storable propellants); third-stage standardized vehicle to be developed; modified TITAN II guidance; payload, 25,000 lbs. in 100-n.mi. orbit, 2,100 to 22,300-mi. orbit; 5,000 lbs. to escape. STATUS: Development; first flight Sept. 1, 1964 (T-IIIA) achieved primary and secondary objectives, but failed to achieve orbit; second flight (T-IIIA) successful Dec. 10, 1964; third flight successful, Feb. 11; Transtage maneuvers included 3 starts, orbited LES-I communications satellite; 17 development flights planned; five TITAN II core vehicles (A version), 12 full TITAN III's (C version); eight other satellite payloads have been approved for launch during flight test program; development stretchout moves operational date to June, 1967; an unmanned rated version—TITAN III-X—being studied as more cost/effective booster for satellite launches; uses first two TITAN III-A stages and an AGENA upper stage; first launch, mid-1966. Twenty-four vehicles planned as initial buy.



missiles

AADS-70 (Army)

Hughes/Douglas/FMC, RCA/Beech, competitive component development contracts. DESCRIPTION: Field army ballistic missile defense system, mobile. STATUS: No decision to develop system has been made; component development funded at $5 million in FY '65; additional FY '66 funding expected to provide basis for system definition studies in FY '66.

ADVANCED SURFACE MISSILE SYSTEM (Navy)

Raytheon, Boeing, Sperry Rand, General Electric, Westinghouse, RCA & Hughes, pre-program definition contracts. DESCRIPTION: Fleet air-defense weapon for the 1970 time period; to have capability against aircraft and certain types of air-to-surface missiles; will replace the 3-T systems currently in the fleet. STATUS: Pre-program definition; program definition planned in mid-1965 and development contract by 1966; $12 million requested in FY 1966 to complete PDP phase.

ALFA (RUR-4) (Navy)

Navy, prime; Avco, frame; Naval Propellant Plant, propulsion. DESCRIPTION: ASW, surface-to-underwater; weight, 500 lbs.; solid propulsion; H.E. depth charge; range, 1,000 yds.; guidance, free-flight. STATUS: Operational; deployed on destroyers and cruisers; being replaced by ASROC.

ANTI-SATELLITE WEAPON (Army/Air Force)

Boeing, AF program; Hughes, terminal guidance (IR), AF program; Douglas, THOR and ZEUS vehicles and support services; A. D. Little, Operations Analysis. DESCRIPTION: Consists of both NIKE-ZEUS and THOR-AGENA w/terminal stage programs; intercepts have been accomplished at "hundreds of miles," according to Secretary McNamara. STATUS: Operational according to DOD; however, major portions of the AF program are uncompleted at the Johnston Island test site. RFPs for a follow-on were to have been issued in December, 1964.

ARM I (Navy)

No contractor announced. DESCRIPTION: Longer-range, smaller anti-radiation missile than SHRIKE for armament of F-111B and A-7A aircraft. STATUS: Advanced development.

ASROC (RUR-5A) (Navy)

Honeywell, prime; Sangamo Electric, sonar; GE, torpedo; Librascope-General Precision, fire control. DESCRIPTION: ASW, surface-to-underwater; weight, 1,000 lbs.; solid propulsion; warhead, nuclear or conventional torpedo; range between 1,800 yds. and 8 mi.; guidance, unguided. STATUS: Operational on DE, DD, DLG, & heavy cruisers; one "live" weapon fired in 1962 Pacific nuclear tests; extended range version in pre-program definition phase; version adaptable to TERRIER launchers being developed. FY 1966 procurement to complete Navy's stock needs.

ASTOR (Mk-45) (Navy)

Westinghouse, prime. DESCRIPTION: Mark 45 ASW, underwater-to-underwater torpedo; weight, over 2,000 lbs.; solid propulsion; warhead, nuclear; range, about 11 n.mi; guidance, wire. STATUS: In production; deployed on hunter-killer submarines.

ATLAS (PGM-15) (Air Force)

TRW Space Technology Laboratories, systems engineering & technical direction; GD/Astronautics, frame; GE/Burroughs/Arma, guidance Rocketdyne, propulsion; GE/Avco, re-entry vehicle. DESCRIPTION: ICBM; weight, 266,000 lbs.; liquid propulsion; warhead, nuclear; range, 5,500-9,000 mi.; ATLAS "E" and "F" series inertial guidance, ATLAS "D" radio inertial. STATUS: 13 squadrons operational at 11 bases; total number of missiles, 126; phaseout of ATLAS D, E&F's begun and will be completed by April, 1965; ATLAS Standard Launch Vehicle developed for AF space programs; ATLAS launches from WTR being used in conjunction with ATHENA launches at Green River, Utah, in an effort to develop scaling laws for re-entry bodies (Advanced Ballistic Re-entry Systems program).

BOMARC A (AIM-10A) (Air Force)

Boeing, prime; IBM/Westinghouse, guidance; Aerojet/Marquardt, propulsion. DESCRIPTION: Surface-to-air interceptor; weight, 15,000 lbs.; liquid booster/ramjet propulsion; warhead, nuclear; range, 200 n.mi.; guidance, command via SAGE; speed, Mach 2.5; ceiling, over 68,000 ft. STATUS: All A missiles at five bases operational in northeastern U.S. to be phased out by the end of FY 1965; production completed; costs $20 million per year to operate system.

BOMARC B (AIM-10B) (Air Force)

Boeing, prime; General Precision Aerospace/Westinghouse/IBM, guidance; Thiokol/Marquardt, propulsion. DESCRIPTION: Surface-to-air; weight, 16,000 lbs.; solid booster/ramjet propulsion; warhead, nuclear; range, more than 400 n.mi.; guidance, command via SAGE; speed, Mach 2.7. STATUS: Three bases operational; production completed; the 188 B models will be distributed among the eight bases after the A model is phased out.

BULLPUP (AGM-12 B & C) (Navy-Air Force)

Martin, systems cognizance; Maxson Electronics Co., production; AMF, liquid engine; Thiokol, solid propulsion; Naval Propellant Plant, solid propulsion (motor loading). DESCRIPTION: Air-to-surface; range, 3-6 mi.; guidance (visual reference), radio-link command. BULLPUP A: Solid propulsion; warhead, 250-lb. H.E. BULLPUP B: pre-packaged liquid motor; warhead, 1,000-lb. H.E. STATUS: BULLPUP A deployed with Atlantic and Pacific Fleets; operational with U.S. Air Force & NATO units; training version (ATM-12) being procured by both services; being produced in Europe for NATO. Planned procurement of BULLPUP B cancelled in FY 1966.

CHAPARRAL (Army)

A surface-to-air adaptation of the Navy's air-to-air SIDEWINDER. Mounted on vehicles, in a 4- or 6-missile configuration. CHAPARRAL will be an interim solution to forward-area air defense. (See: SIDEWINDER.)

CLOSE-SUPPORT ASSAULT WEAPON (Navy)

Navy Bureau of Weapons and Johns Hopkins Applied Physics Lab, prime; United Aircraft Norden Div., guidance. DESCRIPTION: Ship-to-shore; outside dimensions compatible with TERRIER shipboard installations; solid propulsion; warhead, high explosive, range, 30 mi. minimum; guidance, inertial and terminal. STATUS: Carried as a line item in FY '66 budget; gyro packages for flight test delivered by Norden; funding dependent on results of guidance system flight tests at WSMR aboard SERGEANT missiles.

CONDOR (AGM-53) (Navy)

In-house project, Naval Ordnance Test Station; RFP's issued to nine firms: Martin, Douglas, McDonnell, Hughes, North American Aviation Columbus Div., Northrop, Raytheon, Grumman, and Bendix. DESCRIPTION: Air-to-surface; configuration classified. STATUS: Development; intended for use with Navy version of F-111.

DAVY CROCKETT (M-388) (Army)

In-house project directed by Army Weapons Command at Rock Island, Ill. DESCRIPTION: Surface-to-surface; solid propulsion, bazooka-launched; warhead, sub-kiloton nuclear; guidance, free flight; two launchers — vehicle-mounted or carried by two men. STATUS: Operational in Europe; $13 million provided in FY '64 budget; three per ROAD battalion; seen as defensive rather than offensive weapon to prevent overrun of Europe.

ENTAC (MGM-32) (Army)

Nord Aviation, prime. DESCRIPTION: Anti-tank; weight, 37 lbs. with launcher; solid propulsion; warhead, shaped-charge H.E.; range, 6,600 ft.; guidance, wire-guided; man-portable. STATUS: Operational; procurement complete; will be replaced by TOW.

FALCON (AIM-4 A, C, E, F/26A/47A) (Air Force)

Hughes, prime; Hughes, guidance; Thiokol, AIM-4/26 propulsion; Lockheed Propulsion, AIM-47 propulsion. DESCRIPTION: Air-to-air; weight (AIM-4/47), more than 100 lbs. — (AIM-26), more than 200 lbs.; range 5 n.mi.; supersonic; solid propulsion; warhead, H.E. (except for AIM-26B, which carries nuclear warhead); AIM-4A, and 4E, active radar homing guidance; AIM-4C, and 4F, IR homing; AIM-26 model has nuclear warhead and hybrid IR radar homing. STATUS: Operational buy-out of 4E, 4F and 26 in FY '62; AIM-47 is the armament for YF-12A (A-11); several versions operational on F-101, F-102 and F-106.

GENIE (AIR-2A) (Air Force)

Douglas, prime; Aerojet-General, propulsion. DESCRIPTION: Air-to-air; weight 800 lbs.; unguided; solid propulsion; warhead, nuclear; range, 6 n.mi.; guidance, free flight; supersonic; proximity fuzing. STATUS: Procurement complete; operational on F-101B and F-106; improved version cancelled. Launcher being developed by McDonnell for adaptation to F-4 aircraft.

HAWK (MIM-23A) (Army)

Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion. DESCRIPTION: Surface-to-air; weight, 1,275 lbs.; solid propulsion; warhead, H.E.; range, 22 mi.; guidance, semiactive radar homing; 100-45,000-ft. ceiling; provides defense against medium and low-flying aircraft and cruise-type missiles. STATUS: Operational, deployed in Europe, Panama, Okinawa, South Viet Nam, U.S. (13 battalions); bought by Sweden and Israel; R&D being conducted to adapt selected HAWK units to an anti-tactical ballistic missile; NATO producing; Japan also plans buy; $34 million requested for equipment and $8 million for spares in FY '66; no further procurement in FY '66; $11 million improvement program aimed at limited anti-missile capability.

HIBEX (ARPA/Army)

Boeing, prime; Hercules and Aerojet, propulsion. DESCRIPTION: Experimental program in high-energy propellants; cone-shaped missile; performance classified; solid propulsion. STATUS: Development; accelerations of 800 to 1,000 g's goal; static test of motor successful, Nov. 1964; flight test program of 10 vehicles being conducted at WSMR; first successful flight test, Feb. '65, at WSMR.

HONEST JOHN (MGR-1) (Army)

Douglas/Emerson Electric, prime; Hercules, propulsion. DESCRIPTION: Surface-to-surface; weight, 5,900 lbs.; single-stage solid propulsion; warhead, nuclear; range, 12 mi. (M-31), 20 mi. (M-50); unguided. STATUS: Operational; M-50 being deployed in Europe; to be replaced by LANCE; procurement complete.

HOUND DOG (AGM-28) (Air Force)

North American, prime; Autonetics, guidance; Pratt & Whitney, propulsion. DESCRIPTION: Air-breathing air-to-surface standoff missile; weight, 9,600 lbs.; turbojet propulsion; warhead, nuclear; range, about 600 n.mi.; guidance, all-inertial; ceiling in excess of 50,000 ft.; Mach 2+. STATUS: Operational; to be launched from B-52G intercontinental bombers; procurement complete.

LANCE (XMGM-52) (Army)
LTV Aerospace, prime; Systron-Donner, guidance. DESCRIPTION: Highly mobile general-purpose missile; very light weight; prepackaged storable liquid propellant; warhead, nuclear and H.E.; range, 3-30 mi.; guidance, Automet inertial, one missile per launcher. STATUS: Large-scale development, no FY 1966 production planned; eventually will replace HONEST JOHN and LACROSSE and perhaps LITTLE JOHN; division support weapon; to use multi-system test equipment.

LITTLE JOHN (MGR-3) (Army)
Emersion Electric, prime; Hercules Powder, propulsion. DESCRIPTION: Surface-to-surface; weight, 800 lbs.; solid propulsion; warhead, nuclear; range, 10 mi.; unguided; supplements medium and heavy artillery in airborne divisions and air-transportable commands. STATUS: Two battalions activated in 1961; each equipped with four launchers; air- and helicopter-transportable; may be replaced by LANCE.

M72 (Army)
Hesse/Eastern Div., Flightex Fabrics, prime. DESCRIPTION: Light anti-tank rocket; weight, 4.5 lbs.; solid propulsion; warhead, H.E.; range, 500 yds.; guidance, free flight; carrier tube launcher; earlier called LAW. STATUS: Operational.

MACE (MGM-13A, CGM-13B) (Air Force)
Martin, prime; Goodyear/AC Spark Plug, guidance, Thiokol/Allison, propulsion. DESCRIPTION: Air-breathing surface-to-surface; weight, 18,000 lbs.; turbojet and solid propulsion; warhead, nuclear and H.E.; range, over 650 n.mi. (Model A), over 1,200 n.mi. (Model B); guidance, map-matching (A), Inertial (B). STATUS: Five MACE-A and one MACE-B squadrons (in hard sites) deployed in Europe; two MACE-B squadrons on Okinawa in hard sites.

MAULER (MIN-46) (Army)
GD/Pomona, prime; Lockheed, propulsion; deHavilland, IR acquisition study; Raytheon, radar; Burroughs, computer; FMC, carrier vehicle. DESCRIPTION: Surface-to-air; weight, 120 lbs.; solid propulsion; warhead, conventional H.E.; guidance, homing; highly mobile anti-aircraft missile; tracked vehicle; 9 missiles per launcher. STATUS: Development; suffering serious packaging problems: Army postponing more advanced models until after feasibility validation program has determined if system can be saved; no FY '66 funding.

MAW (Army)
McDonnell Aircraft Co. and Army Missile Command, development of competitive approaches to Medium Anti-Tank/Assault Weapon requirement; Ford Instrument Co., gyro package for Army version. DESCRIPTION: Surface-to-surface; solid propellant; range, 500-1,500 yds.; shoulder-fired; McDonnell version wire-guided; Army version two-degree-of-freedom, free rotor gyro. STATUS: Exploratory Development; competitive approaches to be fired off against each other in Summer, 1965, using a ZUNI test vehicle, and the best allowed to proceed into full-scale development.

MINUTEMAN (LGM-30) (Air Force)
TRW Space Technology Laboratories, systems engineering and technical direction; Boeing, major contractor; Autonetics, guidance, Thiokil, first-stage propulsion; Aeroject, second-stage propulsion; Hercules, third-stage propulsion; Avco, re-entry vehicle; GE, MARK 12 re-entry vehicle, MINUTEMAN II. DESCRIPTION: 2nd-generation ICBM; weight, over 65,000 lbs.; solid propulsion; warhead, nuclear; 3 stages; range, over 5,000 mi.; guidance, all-inertial, target selected in seconds; 32-sec. reaction time. STATUS: MINUTEMAN II flight-test program (36 shots planned) began Sept. 24, over 700 MINUTEMAN I now operational; 1,000 missiles through FY '65; advanced version can be fired by airborne command posts; deployed in hardened and dispersed silos; MINUTEMAN II expected operational 1965, to be co-located with MMI; also some of the II's replace earlier models; MMII has greater accuracy and range/payload than I version. First overland shot, Mar. 1.

NIKE-HERCULES (MIM-14B) (Army)
Western Electric, prime; Western Electric, guidance; Hercules and Thiokol, propulsion; Douglas, airframe. DESCRIPTION: Surface-to-air, antiaircraft, tactical; weight, 10,000 lbs.; solid propulsion; warhead, nuclear or H.E.; range, 75 mi.; guidance, command; Mach 3+; ceiling in excess of 150,000 ft. STATUS: Over 80 batteries deployed in U.S. being turned over to National Guard; over 10 N-H batteries deployed overseas; Japan plans additional procurement; being equipped with HIPAR, a high power acquisition radar, and antitactical-ballistic-missile capabilities. Re-location of some Hercules batteries under consideration by JCS.

NIKE-X/Zeus (XLIM-49) (Army)
Western Electric, prime; Bell Telephone, guidance; Thiokol/Lockheed, propulsion; Douglas, airframe. DESCRIPTION: Antimissile missile, 3-stage; weight, 22,800 lbs.; solid propulsion; warhead, nuclear; range, 200-mi.; guidance, command; length, 48 ft.; diameter, 36 in.; fin span, 10 ft. STATUS: Missile is now part of NIKE-X missile "mix"; development, except as part of X, has ended; no intercept "failure" in more than a year of tests; $10 million requested for preliminary production engineering in FY 1966.

NIKE-X (Army)
Western Electric, prime; Bell Telephone, guidance; Thiokol, ZEUS propulsion; Douglas, ZEUS airframe; Martin Marietta, SPRINT missile prime; Hercules and Lockheed, SPRINT propulsion. DESCRIPTION: Successor to ZEUS as an anti-ICBM system; uses a mix of ZEUS/SPRING missiles and multi-function array radar (MAR). STATUS: Engineering development; funded at $334 million in FY '65 on accelerated development schedule, but deployment still deferred; tests to be conducted late this year with MAR at WSMR, New Mexico, could provide basis for deployment decision; deployment cost: $12-20 billion.

PERSHING (MGM-31) (Army)
Martin, prime; Bendix, guidance; Sperry Farragut, fuzing and aiming; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; two-stage solid propulsion; warhead, nuclear; range, approx. 400 n.mi.; guidance, inertial; transported on FMC M474 tracked vehicles; replaced REDSTONE. STATUS: Flight test program completed; troop firings from Ft. Wingate, N.M., to White Sands being conducted; number of missile-loaded launchers per unit to be increased; West Germany organizing two battalions; first U.S. PERSHING battalion deployed to Germany in April.

PHOENIX (AIM-54) (Navy)
Hughes Aircraft Co., prime; Rocketdyne, propulsion. DESCRIPTION: Air-to-air missile for use with the F-111B fighter aircraft; each aircraft will be able to carry six missiles. STATUS: Development. $71 million in FY '66 funds; Phoenix development problems delaying F-111B production.

POLARIS (UGM-27 A, B, C) (Navy)
Lockheed, prime; GE/MIT/Hughes/Honeywell/Raytheon, guidance and fire control; Aerojet-General/Hercules, propulsion; Lockheed, reentry vehicle; Nortronics, checkout; Autonetics/Sperry, SINS; Westinghouse, launching equipment; Vitro, systems engineering coordination and training; Systron-Donner, ignition programming. DESCRIPTION: Underwater- and surface-to-surface; weight, 30,000 lbs.; solid propulsion; warhead, nuclear; range, 1,200 n.mi. (A-1), 1,500 n.mi. (A-2), 2,500 n.mi. (A-3); guidance, all-inertial. STATUS: 19 subs operational each with 16 missiles; A-1 aboard first five submarines; A-2 aboard subs 6-18; A-3, operational in August, 1964, aboard subs 19-41; total of 41 POLARIS subs authorized; deployed in Atlantic and Mediterranean; Pacific deployment began in 1964; British to buy A-3 missiles from U.S. B-3 (now called POSEIDON) ready for program definition with FY '65 funds; designed for twice the accuracy of POLARIS A-3. Lockheed remains POSEIDON prime.

QUAIL (ADM-20C) (Air Force)
McDonnell, prime; McDonnell Electronics, guidance; GE, propulsion; Thompson Ramo Wooldridge, ECM equipment. DESCRIPTION: ECM-carrying decoy, which simulates B-52 bomber, to enemy radar; turbojet powered; range, 250 mi.; guidance, gyroscopic autopilot. STATUS: Deployed at SAC bases; carried by B-52; procurement completed FY '61; advanced version with 400-mi. range has been flight tested.

REDEYE (MIM-43) (Army)
GD/Pomona, prime; Atlantic Research, propulsion. DESCRIPTION: Surface-to-air; weight, 28 lbs.; solid propulsion; warhead conventional; guidance, IR-homing; length, 48 in.; diameter, 2.75 in. STATUS: Production tests against helicopters and jets at NOTS successful. Procurement begins with reprogrammed FY '65 funds and $67-million FY 1966 request.

REGULUS I (RGM-6) (Navy)
LTV Aerospace Corp., prime; Sperry, guidance; Allison, propulsion. DESCRIPTION: Surface-to-surface; weight, 14,000 lbs.; turbojet and solid propulsion; warhead, nuclear; range, 500 n.mi.; guidance inertial; speed, about 600 mph; ceiling, approx. 40,000 ft. STATUS: Five REGULUS subs with 17 missiles are operational now; 3 subs (8 missiles) will be phased out in FY '65.

SERGEANT (MGM-29A) (Army)
Sperry Utah, prime; Sperry, guidance; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; solid propulsion; warhead, nuclear; range, over 75 n.mi.; guidance, inertial; uses drag brakes. STATUS: Operational procurement complete; deployed in Europe; replacement for CORPORAL; West Germany buying system. $1.9 million requested in FY 1966 for warhead adaption kits.

SHILLELAGH (MGM-51A) (Army)
Philco Aeronutronic, prime Picatinny Arsenal/Amoco Chemicals Corp., propulsion; Aeronutronic, guidance. DESCRIPTION: Surface-to-surface; lightweight; solid propulsion; warhead, nuclear or H.E.; guidance, command; vehicle-mounted for use against field fortifications, armor and for close-in support of troops. STATUS: Production. Initial procurement in FY '65; to use multi-system test equipment; engineering development stage began in FY '64; to be installed on Gen. Sheridan assault vehicle; also being considered for use on helicopters.

SHRIKE (AGM-45A) (Navy)
Naval Ordnance Test Station-China Lake, prime; Texas Instruments, guidance and control; North American Rocketdyne (McGregor), propulsion. DESCRIPTION: Air-to-surface, anti-radar; solid propulsion; guidance, passive radar homing. STATUS: Operational; armament for Navy and Air Force tactical aircraft.

SIDEWINDER I-C (AIM-9D) (Navy, Air Force)
Naval Ordnance Test Station, technical direction; Philco, guidance; Naval Ammunition Depot, McAllister, motor loading; Rocketdyne (McGregor), propellant. DESCRIPTION: Air-to-air; weight, about 155 lbs.; solid propulsion; warhead, H.E.; range, more than 2 mi.; guidance, IR. STATUS: 1-A deployed with Navy and Air Force; 1-C version being procured as replacement for 1-A; NATO-built version now in production. (See CHAPARRAL).

SPARROW III-6B (AIM-7E) (Navy)
Raytheon, prime; Raytheon, airframe, control, guidance; Aerojet-General/North American Rocketdyne (McGregor), propulsion; McDonnell/Benrus Watch Co., launcher. DESCRIPTION: Air-to-air; weight, 350 lbs.; solid propulsion; warhead, conventional; range, 5-8 mi.; guidance, semi-active CW homing; Mach 2.5-3; ceiling, over 50,000 ft. STATUS: Earlier models operational with carrier aircraft; SPARROW III-6B prime armament for Phantom II (F-4B) and other high-performance interceptors; British F-4 buy expected to include SPARROW missiles; U.S. procurement terminates with FY '66 buy.

SPRINT (Army)
Martin-Orlando, prime; Hercules Powder/Lockheed Propulsion Co., propulsion; Bell Telephone Laboratories, guidance. DESCRIPTION: High-acceleration cone-shaped missile for low-altitude interception of ballistic missiles; 4.5-ft. base diameter, 27 ft. long; two stage; nuclear; missile will be popped out of silo before motor is ignited; to be part of the missile mix in a NIKE-X battery. STATUS: Development; SQUIRT vehicle to be used to test materials and components for SPRINT at White Sands Missile Range; pop-up tests to prove silo ejection concept and mechanism under way at Martin-Orlando plant.

SRAM (Air Force)
No contractors selected. DESCRIPTION: Air-to-surface defense-suppression standoff missile for use with the B-52, B-58 F-III or the Advanced Manned Strategic Aircraft. STATUS: Advanced development; RFP's to industry due early in 1965 for three-phase program definition; full-scale development to begin early in 1966.

STANDARDIZED MISSILE (Navy)
No contractors. DESCRIPTION: Fleet air-defense missile to replace TARTAR-TERRIER and give Navy a single missile to perform both missions; longer-range targets would be engaged by adding a booster to the shorter-range weapon; similar to the homing TERRIER now being procured. STATUS: Development; expected to be procured initially in 1967-68.

SUBROC (UUM-44A) (Navy)
Naval Ordnance Laboratory, technical direction; Goodyear, prime; General Precision Aerospace, guidance; Thiokol, propulsion; General Precision Librascope, fire control. DESCRIPTION: Underwater-air-underwater antisubmarine missile depth bomb; solid propulsion; warhead, nuclear; weight, 4,000 lbs.; length, 21 ft.; diameter, 21 in.; range, 25-30 mi.; guidance, inertial. STATUS: Production scheduled for installation in Thresher-class subs; operational evaluation under way; $23 million requested for FY '66 procurement.

SS-10 (Army)
Nord Aviation, prime. DESCRIPTION: Surface-to-surface, primarily antitank; weight, 33 lbs.; solid propulsion; warhead, conventional; range, 1,600 yards; wire guided. STATUS: Operational with U.S., French and other NATO and Western units; battle-tested in North Africa; U.S. replacing with ENTAC.

SS-11 (Army)
Nord Aviation, prime. DESCRIPTION: Surface-to-surface antitank, also helicopter-to-surface; weight, 63 lbs.; solid propulsion; wire guided; warhead, conventional; range, 3,800 yds. STATUS: Operational, to be used with airborne units and Army helicopters.

TACTICAL PROBE (Navy)
Bendix, prime: DESCRIPTION: Surface-to-air; multiple, interchangeable payloads for each mission; booster, TERRIER or TALOS from shipboard installations; high-impulse second stage; range, 50-300 mi.; parachute descent. STATUS: Program definition; a new study has been authorized, and is under way, to evolve a cheaper program.

TALOS (RIM-8E) (Navy)
Bendix, prime; Vitro, systems engineering; McDonnell/Hercules Allegany Ballistics Lab., propulsion; Sperry, guidance; GE, launching gear. DESCRIPTION: Ship-to-air; weight, 7,000 lbs.; solid and ramjet propulsion; warhead, nuclear; range, 65 n.mi.; guidance, radar beam riding/semi-active homing; Mach 2.5. STATUS: Operational aboard cruisers Galveston, Little Rock & Oklahoma City and three Albany-class DEG's; Long Beach, nuclear-powered cruiser, has advanced TALOS; "3-T" get-well program increasing reliability; procurement continues in FY '66.

TARTAR (RIM-24B) (Navy)
Vitro, systems coordination engineering; Applied Physics Lab, design and development; GD/Pomona, Aerojet-General, propulsion; Sperry Farragut, fuze (target detection device). DESCRIPTION: Ship-to-air; weight, 1,500 lbs.; solid dual-thrust motor; warhead, conventional; range, 10 n.mi.; guidance, semi-active homing; Mach 2. STATUS: Operational; installed aboard 23 guided missile destroyers and three cruisers equipped with TALOS; get-well program progressing satisfactorily; CVA Kennedy will also have TARTAR.

TERRIER (RIM-2E) (Navy)
Vitro, systems engineering; GD/Pomona, prime; GD/Pomona, guidance section; Sperry, radar; Hercules Allegany Ballistics Laboratory, propulsion; Northern Ordnance, launching gear. DESCRIPTION: Ship-to-air; weight, 3,000 lbs.; 27 ft. long; solid propulsion; warhead, conventional; range 10 n.mi.; guidance, radar beam-riding or homing; Mach 2.5. STATUS: Operational aboard two attack carriers, 6 cruisers, and 12 missile frigates; get-well program progressing satisfactorily.

TITAN I (HGM-24A) (Air Force)
TRW Space Technology Laboratories, systems engineering and technical direction; Martin, prime; Bell/Sperry, guidance; Aerojet-General, propulsion; Avco, re-entry vehicle. DESCRIPTION: ICBM; weight, 220,000 lbs.; LOX/RP-1 fueled; warhead, nuclear; range, 5,000 mi.; guidance, radio inertial; 90 ft. long; 2 stages. STATUS: Operational; 54 missiles at 5 bases. All will be deactivated by July, 1965.

TITAN II (LGM-25C) (Air Force)
Martin, prime; TRW Space Technology Laboratories, system engineering and technical direction; AC Spark Plug, guidance; Aerojet-General, propulsion; GE, re-entry vehicle. DESCRIPTION: ICBM; weight, 330,000 lbs.; N_2O_4 and Aerozine-50 storable fuels; warhead, nuclear; range, over 5,000 mi.; guidance, inertial; 115 ft. long; 2 stages; greatest payload and range of any U.S. ICBM, basic core vehicle for TITAN III booster. STATUS: All 54 missiles operational; one squadron (18 missiles) operational at Davis-Monthan AFB; one (18 missiles) at McConnel AFB and one (18 missiles) at Little Rock AFB.

TMRBM (Air Force)
No contractors announced, but probably would be same team producing the second and third stages of MINUTEMAN II. DESCRIPTION: A transportable mid-range missile to fill the gap left by cancellation of MMRBM; it would use the top two stages of MM II and the MM II guidance system; would weigh more and be less mobile than MMRBM, but could be developed for approximately one-third the cost; reaction time also less than MMRBM's; employment concept much the same as that of the Russian-deployed missiles in Cuba in 1962. STATUS: Study by the Air Force at DDR&E direction; not likely to be developed due to a lack of mission.

TOW (Army)
Hughes, prime. DESCRIPTION: Antitank; weight, 160 lbs.; solid propulsion; warhead, H.E.; wire guided; optically tracked; tube-launched. STATUS: Development; follow-on to ENTAC; firings being conducted at Army Missile Command.

WALLEYE (Navy)
Naval Ordnance Test Station-China Lake. Navy has negotiated PDP contracts with Martin, NAA & Hughes. DESCRIPTION: Guided air-to-surface bomb; weight, 1,000 lbs., equipped with movable fins; propulsion type, none; warhead, high-explosive; range, several miles; guidance, TV contrast homing guided by pilot. STATUS: Engineering development; two production contracts will be awarded as well as one for additional development. Scheduled for FY 1966 deliveries to begin replacing BULLPUP B.

ZUNI (Navy)
Naval Ordnance Test Station, prime; Hunter-Douglas, propulsion. DESCRIPTION: air-to-surface; weight, 107 lbs.; solid propulsion; warhead, conventional; range, 5 n.mi.; unguided; STATUS: Operational; designed for use on jet fighter and attack aircraft.

ORDER REPRINTS OF THE ASTROLOG FROM:

Research Department
Missiles and Rockets
1001 Vermont Avenue, N.W.
Washington, D. C. 20005

Price: 35 cents per copy. Payment must accompany order.

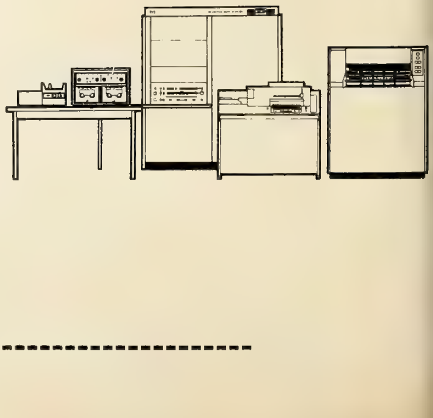
Too bad about your IBM 1620

We didn't set out to make your 1620 system obsolete. But facts are facts. And, fact is, you can replace your 1620 to great advantage with an SDS system. What does that buy you? Plenty: *at least four times the throughput at 25% less cost.*

A typical SDS system consists of an 8K memory SDS 910 computer with Magpak magnetic tape system, line printer, 100-card-per-minute reader and Teletype keyboard/printer with paper tape reader/punch. It leases for $3,041/mo. and does everything your 1620 does, faster. You can use the MONARCH monitor routine and FORTRAN, SYMBOL or METASYMBOL. You can batch process programs written in FORTRAN and/or METASYMBOL automatically and interchangeably. And your throughput will be from 4 to 22 times faster.

For additional capacity and speed you can use an SDS 920, 925 or 930 system. The monthly lease prices are $3,281, $3,411 and $3,541 respectively. And no matter which SDS system you order, the benefits are the same: a better system with greater efficiency for fewer dollars.

Want concrete proof? We're planning a demonstration in a city near you soon. For details, pick up a phone or drop us a line.



SDS SCIENTIFIC DATA SYSTEMS 1649 Seventeenth Street, Santa Monica, Calif.

Sales offices in New York, Boston, Washington, Philadelphia, Pittsburgh, Huntsville, Orlando, Chicago, Houston, Albuquerque, San Francisco. Foreign representatives: Instronics, Ltd., Stittsville, Ontario; CECIS, Paris; F. Kanematsu, Tokyo; RACAL, Sydney.

Circle No. 6 on Subscriber Service Card

Fireflies to Light the Way in NASA Effort to Chart Earth's Biosphere

by William S. Beller

AN INGENIOUS solution to the problem of determining instantly if organic life is present during the traverse of an altitude was disclosed a few days ago at the Goddard Space Flight Center.

Such determination is one difficulty confronting NASA life scientists designing experiments and devices to draw a biological profile of the Earth's atmosphere.

Curiously, the technique involves the same chemistry the firefly uses when he lights his lamp to beckon a mate. Appropriately, the project is called "Firefly," as is the instrument derived from it.

The reaction to the presence of life is almost immediate with Firefly. By contrast, classical biological methods for detecting organisms take hours, sometimes days.

The chief mission of Firefly is to help complete the picture of the Earth's biosphere. Another is to learn at what altitude the shrouds can be ejected from spacecraft such as *Ranger* and *Surveyor* without contaminating the vehicles with terrestrial organisms. (These shrouds are cast off at an altitude of about 115 miles, presumably above the biosphere.) The third reason for the project is to find out if there is any extraterrestrial organic life in the Earth's atmosphere.

• **Schedule**—Balloon flights employing Firefly are scheduled this year to get data about the biosphere. This will be followed by Firefly-bearing rocket flights in 1966, and an eventual *Gemini* orbital flight.

On the balloon and rocket flights, other means of life detection will also be used. These will involve particle collection devices such as filters and, possibly, cyrogenic plates for quick-freezing atmospheric samples at specified altitudes. In these experiments, unlike Firefly, the instruments will have to be recovered for their data.

All altitudes are to be sampled, including the noctilucent cloud regions. These are at about 80,000 feet where organic life is not expected.

Nevertheless, if life or its remains are in the higher reaches, then the present model of the biosphere is radically wrong, one of the experimenters told MISSILES AND ROCKETS. Norman MacLeod, head of Goddard's biosciences group and leader of this study of the biosphere, gave three reasons that could account for high-altitude life: It was released from the vehicle making the traverse. It came from outside Earth. It was transported from Earth in a way we have not considered.

The instrument coming out of Goddard's Firefly contract is reminiscent of the imagination used in Gulliver—a probe that detects life when microorganisms, feeding on appropriately spiked broth, release radioactive carbon dioxide. Gilbert V. Levin, director of special research at Hazelton Laboratories, Inc., Falls Church, Va., was instrumental in developing both devices.

Although Goddard life scientists do not have the mission of making up experiments or means for detecting life in atmospheres other than Earth's, Levin sees the Firefly as highly useful for these extensions. Since it is "the only life detection method we know of that can detect life while the instrument is in flight," he suggests putting it on a vehicle either passing through a strange atmosphere or heading for a crash landing on an extraterrestrial body.

He foresees yet another application of Firefly and remarked how very useful it would be emplaced next to Gulliver in an effort to find Earth-like life on bodies other than our own.

The theory of Firefly is very simple. The tail of the insect firefly contains chemicals that give out light when adenosine triphosphate (ATP) is introduced. ATP is only a few reaction stages away or is directly coupled with every known biological transfer. It is rarely, if ever, found where there is no biological activity. Therefore, if the chemicals within the tails of fireflies are used as sensors for ATP, then when light is generated, biological activity is indicated.

In chemical terms, a firefly's tail contains reduced luciferin and the enzyme luciferase with magnesium ions attached. When ATP is brought in, the reduced luciferin is oxidized, adenosine monophosphate is formed, and light is emitted.

Firefly tails are actually used. The reason is that luciferase, like most enzymes, has not been synthesized. This has given rise to the pressing problem of getting enough of the tails to carry on the experimental work.

• **How it works**—As an instrument, Firefly goes through five elementary steps. The sample is collected. It is then processed, either chemically or physically, to release its ATP. The ATP contacts reduced luciferin and its enzyme and one photon is emitted for every luciferin molecule reacting. The light of the reaction is exposed to a photomultiplier tube. The result is read and telemetered to a receiving station.

The last three operations, and possibly the last four, would all occur at the same time. The finished instrument would weigh less than a pound, according to estimates.

During the past year Levin and Goddard scientists have increased the sensitivity of Firefly by several orders of magnitude. MacLeod said his objective is to detect by Firefly the amount of ATP in only a single organic cell. This is about 10^{-17} grams of the chemical.

"We have measured down to 10^{-12} grams of ATP," said Grace Lee Picciolo, one of Goddard's chief researchers on Firefly. "Since that measurement, Emmett Chappelle, Hazelton biochemist, got rid of three orders of magnitude of biochemical noise, but we haven't gone back yet to see what this means in terms of ATP measurements." She said it looked promising that Firefly might now be able to measure as low as 10^{-15} grams of ATP, just two orders of magnitude from MacLeod's stated goal.

On a search of another planet, Gulliver might indicate that some organisms are generating carbon dioxide. If ATP were also known to be present, then biologists could conclude with almost certainty that life as we know it on Earth does indeed exist on this other body. ■

CO-PILOT

Today's Minuteman is more than a super-reliable missile.

It is a spearhead of electronics progress—technology that is making it a co-pilot by proxy in low-level supersonic aircraft.

It is the forerunner of microelectronic low-level penetration systems by NAA/Autonetics that spot and evade obstacles with unprecedented accuracy. These new NAA/Autonetics systems are based on proven Minuteman techniques and systems management experience.

Autonetics built the fully-integrated microelectronics systems in Minuteman II; was the first to apply microelectronics to production-line systems. Its achievements in this field are setting a whole new standard of reliability in the electronics industry.

For more information about Autonetics total systems capability in meeting the electronics needs of the future, please write: Director of Marketing, NAA/Autonetics Division, 3370 Miraloma Avenue, Anaheim, Calif.

North American Aviation Autonetics Division

Air Force Expands Range Dominance

Takeover of control at Point Arguello for Western Test Range boosts AF budget funding; an updated report on U.S. range operations

by Donald L. Zylstra

LONG THE OPERATOR of the lion's share of United States national range facilities, the Air Force took over another sizeable bite of the military ranges budget when it officially assumed operation of the Air Force Western Test Range (AFWTR) on Feb. 1.

In his report to Congress on U.S. aeronautics and space activities during 1964, President Johnson identified five distinct entities in the national range complex: the Army-managed White Sands Missile Range (N.M.) and Kwajalein Test Site; the Navy's Pacific Missile Range; the Air Force Eastern Test Range and its newly reorganized Western Test Range—plus the Sunnyvale, Calif., Satellite Control Facility, also operated by the Air Force.

Transfer of Navy's Point Arguello, Calif., Pacific Range, and instrumentation facilities to Air Force operational control on Feb. 1 caused a reduction in funding requests for Navy's Pacific Missile Range, from $123 million for Fiscal Year 1965 to $77 million in FY '66. Portions of the difference between the two funding figures have been added to the Air Force request for its WTR, which is $62 million in the FY '66 budget. Although direct comparison of the relative size of the various range operations is not possible—because no FY '66 line-item figures are given for the Army's Kwajalein test site, the Air Force satellite control facilities and others—figures for the installations specifically called ranges *are* available.

FY 1966 funds requested for Army's White Sands range total $88 million; for the Navy's Pacific Missile Range (PMR), $77 million; and for operation of the Air Force National Range Division, including both the Eastern Test Range and the Western Test Range, $283 million. The Air Force total is divided between the Eastern Test Range—$221 million, and the Western Test Range—$62 million.

• **Other facilities**—These amounts do not include funding requests for Army's Kwajalein Test Site—or for the Sunnyvale Satellite Control Facility, the Edwards AFB (Calif.) Flight Test Center or the Eglin Air Proving Ground Center (Fla.), all operated by the Air Force—or for the Navy's China Lake (Calif.) Naval Ordnance Test Station (NOTS).

Other ranges also operated by the armed forces include Navy's Atlantic Undersea Test Evaluation Center (AUTEC)—actually three underwater test ranges located in a deep underwater canyon off the Bahamas. AUTEC is scheduled for requests totaling $8 million in FY '66, compared with $11 million in FY '65, when more construction was still in progress. The Air Force Churchill Research Range at Ft. Churchill, Manitoba, Canada, extends eastward for 400 mi. across Hudson Bay.

The Air Force-Canadian-NASA facility at Churchill is devoted entirely to basic research, using the solid-fueled *Nike-Apache, Nike-Cajun, Arcas, Black Brant, Astrobee* and *Javelin* rockets and the liquid-fueled *Aerobee.*

The range and its vehicles are capable of launching scientific instruments weighing from 50 to 150 lbs. up to 600-mi. altitudes. Support for the range is provided by Pan American Airways, assisted by the Canadian Army and other Canadian agencies. Situated as it is, only 1,100 mi. from the magnetic North Pole, in a maximum auroral zone, the Churchill range concerns itself with experiments appropriate to its area, including electron and atmospheric density, magnetic flux, auroral physics, cosmic radiation, meteor physics and electrical conductivity.

Mission for the Eglin Air Proving Ground Center includes: 1) testing of aircraft and missile systems and subsystems, conventional weapons and electronic equipment; 2) conducting scientific space probes; 3) operating pilotless supersonic aircraft; and 4) providing tracking support for orbiting space flights.

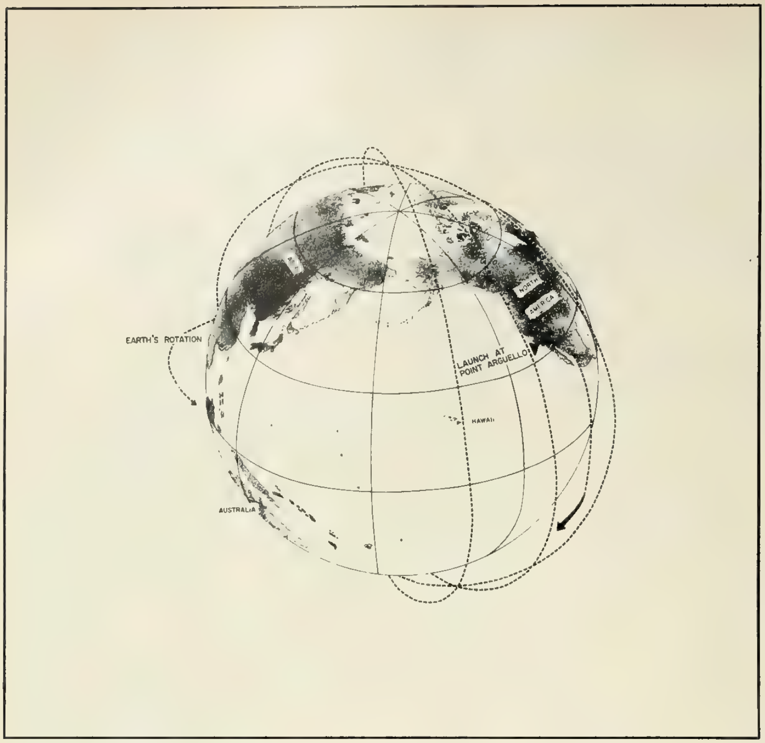
Eglin embraces 750 sq. mi., including eight land test ranges. It extends from Eglin to Key West, Fla.

The Air Force Eastern Test Range stretches away from Cape Kennedy, 10,000 n. mi. to the southeast. With 13 permanent tracking stations strategically located along the range, the ETR (formerly Atlantic Missile Range) continues to be responsible for range support of all man-rated launches—as well as an impressive list of other U.S. flights. After launch at Cape Kennedy, rockets or space vehicles can be tracked over long or short trajectories by island-based range stations. These include Cape Kennedy, Jupiter Inlet, Fla., Grand Bahama, Eleuthera, San Salvador, Mayaguana, Grand Turk, Puerto Rico, Antigua, Trinidad, Fernando de Noronha and Ascension. A final range station is located near Pretoria, South Africa.

• **Western advantages**—As scheduling on the AFETR intensifies, the Air Force is constantly increasing the number and the quality of the communications channels between its down-range island stations. One such improvement included laying an additional 800 mi. of underwater cable, connecting Grand Turk, Puerto Rico and Antigua with 60 reliable two-way channels for voice and teletype communications.

But if the Eastern Test Range excels in the quality of the tracking and telemetry it can provide from permanent stations lining the range, the Western Test Range at Vandenberg AFB also has specialties all its own. South of the Point Arguello facility, the Pacific Ocean stretches away, providing an uninterrupted water surface to the South Polar ice cap—an ideal expanse over which to launch payloads into polar orbits.

With DOD's Advanced Research Projects Agency (ARPA), the military services and NASA focusing more and more attention on the phenomena associated with re-entry, the Western Test Range affords military and civilian scientists the best re-entry look at very large rockets, missiles and other vehicles launched over the Pacific. Coupled with the facilities of AFWTR, Army's Kwajalein Test Site is superbly equipped to offer a terminal look at re-entering missiles or vehicles. Besides its mission of acquiring and tracking approaching



ARTIST'S DRAWING of polar-orbit vehicle trajectories made possible by launch from Point Arguello, now transferred from Navy to Air Force Western Test Range. South of facility is uninterrupted water surface stretching to South Pole.

Vandenberg-launched target missiles with its *Nike-X* system radars, the Kwajalein facility provides re-entry observations and data for AF technical people and their missile contractors. The FY '66 budget requests $9 million for procuring "target" payloads to be launched over the WTR toward Kwajalein by *Atlas* boosters.

Roi-Namur Island, 50 mi. north in the Kwajalein atoll, is an important Pacific station at which ARPA conducts a program of electromagnetic signature studies as part of its Project Defender. The research project at the facility is called PRESS (Pacific Range Electromagnetic Signature Studies).

- **PMR functions**—In transferring the 20,000-acre Point Arguello and other facilities to the Air Force, the Navy also turned over its Point Pillar tracking station in California and mid-Pacific stations at Canton Island, at Eneweitok, and at South Point and Kokee Park in Hawaii. Missile impact location stations (MILS) at Wake and Midway are still under Navy control, awaiting a decision which may see them divided between the Navy and the Air Force.

For operation of its Pacific Missile Range, Navy retains tracking stations at Barking Sands missile tracking facility, Kauai, Hawaii, and is a tenant at Johnston Island. One of the major communications links for the operation of PMR is at Kaneohe Bay on the Hawaiian island of Oahu. This site is headquarters for control of the Hawaiian Islands sector of PMR. At Barking Sands, Navy operates a new underseas facility for testing such fleet weapons as the *Asroc* submarine rocket, the *Subroc* submarine-launched rocket and new types of Navy torpedoes. About 160 separate projects are currently assigned to the range.

Other PMR stations include those at San Nicolas and San Clemente Islands on the Sea Test Range. This range is close inshore and parallels 500 mi. of California coast, from south of Los Angeles to north of San Francisco, extending an average 250 mi. out to sea. Here, over a group of instrumented flight corridors radiating from the Point Mugu Naval Missile Center, Navy tests short-range air-to-air and air-to-surface guided missiles and medium-range surface-to-surface missiles for all of the armed forces.

PMR, commanded by Rear Adm. John E. Clark, is responsible for all sea-based launches on the range—in the Pacific and Indian oceans. As an extension of PMR, for testing surface-to-surface missiles, Navy established a three-state corridor, extending from Point Mugu eastward to Tonopah, Nev., and Dugway, Utah. First guided missile operations over this extension of the range were conducted in 1958.

Among the test programs supported by PMR are the *Terrier-Tartar-Talos* improvement effort, work on the new standardized ship-to-air missile, the new *Phoenix* air-to-air missile for Navy's version of the F-111, and continued testing of advanced *Polaris* and *Poseidon* missiles.

- **Range ships**—In line with the newest DOD moves to consolidate certain aspects of the national range effort under the armed services most logically involved, Navy has been directed to establish an Instrumentation Ships Project Office under its Bureau of Ships in Washington. Navy's Military Sea Transportation Service (MSTS) is now responsible for the operation of all range vessels serving Air Force, Navy and Army arms of the national range complex. Operational assignments of these ships in either the Atlantic or Pacific oceans now are a responsibility of the Air Force NRD.

Eighteen range ships now serve the national range complex, seven in the Pacific and 11 in the Atlantic. All ships in the Atlantic were recently transferred to MSTS. These and six in the Pacific are being scheduled directly by the AFNRD. The seventh, the USNS Wheeling, is assigned directly to Navy's Pacific Missile Range. Air Force scheduling prerogatives at present do not apply to this vessel.

In preparation for the NASA *Apollo* program, three new range vessels are being converted from T-2 tankers through a "jumboizing" process which involves adding long new midsections to accommodate new monitoring equipment. The three ships—the USNS Mission Del Pala, Mission San Fernando and Mission San Juan—are to be operational in calendar 1966. Two converted Victory ships assigned to range duties in the Pacific—USNS Huntsville and USNS Watertown—will also be refitted to support *Apollo*.

- **White Sands**—One of the largest and most complex systems of ground-based data-collecting facilities is incorporated at Army's White Sands Missile Range (WSMR), with more than 640 active instrument stations and more than 1,075 surveyed sites from which tracking and data-gathering instruments can be operated. Permanent stations are of many types—including optical, radar, telemetry, electronic trajectory, timing and communications and control. More than 1,100 mi. of roads, nearly 75,000 mi. of wire and cable and some 250 microwave and radio channels serve the range.

Easily the busiest of the national range locations, WSMR, under command of Maj. Gen. John F. Thorlin, is currently host to about 174 projects involving the three armed services, NASA, and other government agencies. Army lists 92 projects, Navy, 13, the Air Force, 57 and NASA and others, 12. Launchings exceed 2,000 annually.

An *Apollo* propulsion development facility to be operated by NASA is now under construction at WSMR, with successful tests of the *Apollo* abort system already carried out in the *Little Joe* program. Scope and capacity of White Sands can be expanded by launching into the range from detached sites at Green River and Blanding, Utah, and Fort Wingate, N.M.

- **Global command**—In his capacity as commander of AFNRD, Lt. Gen. Leighton I. Davis is responsible for a central authority, coordinating Air Force planning of activities of the Eastern Test Range, ICBM and space activities in the Pacific on its Western Test Range, and the Air Force Satellite Control Facility.

The Sunnyvale facility continues under Air Force Systems Command Space Systems Division control. Its operations are not directly under Davis's line command. But as AFNRD commander, he exercises a review and planning responsibility for the facility.

When any of the national range facilities becomes the "lead range" for a specific launch or other operation, its commander directs the entire effort—on a global scale if necessary. Thus, when the Air Force NRD supports NASA manned space effort, Davis becomes DOD's global manager for manned spaceflight support and can call on all other national range facilities and military commands for assistance.

No service such as the Navy, proud of its achievements, can be said to enjoy the prospect of turning over a facility such as Point Arguello lock, stock and barrel to a sister service, after spending years in its highly successful development. But the Navy has done so with remarkable efficiency and good grace.

- **Name pre-empted**—One continuing source of irritation to Navy and Army range management people, however, is what they regard as a remarkable "coincidence." For many years now, official exchanges of manuals and information between Cape Kennedy, White Sands and Point Mugu have born the imprint "NRD"—signifying National Range Document, or national range documentation.

Many range officers in the Navy and Army are privately convinced that it was no accident that the Air Force chose to call its new range management command the "Air Force National Range Division" (AFNRD)—and then irritatingly began leaving off the Air Force prefix, shortening it simply to "NRD." ■

Radiation, Inc., Equipping Nimbus-B Satellite

by Michael Getler

PALM BAY, FLA.—A project to allow remote collection via satellite of meteorological data from ground-based, buoy-mounted or possibly airborne sensors, has been launched by NASA's Goddard Space Flight Center.

Under terms of a contract expected to be signed this week and valued at about $1.7 million, Radiation, Inc., located here, will provide an Interrogation-Recording-Location System (IRLS) for Goddard which will eventually operate with the *Nimbus-B* experimental weather satellite.

Radiation will supply equipment for the satellite, remote sensors and the necessary interface equipment for existing *Nimbus* ground receiving stations in Alaska and North Carolina. The system involves collection of local-area meteorological data by the unattended sensors, which can either be fixed-base or moving (possibly aboard a balloon); encoding of the data and transmission to the satellite upon command; storage of the data aboard the satellite until it passes over a ground station once every 90 minutes; and subsequent transmission to the ground.

While IRLS is currently slated solely for *Nimbus*, which is strictly an experimental program, the basic concept of using satellites to monitor unattended and remote sensors has attracted side interest. This is true both in the military, where the Navy has expressed interest in satellite-monitored ocean surveillance devices (M/R, Sept. 21), and in the commercial field, possibly with future synchronous-altitude weather satellites for gathering synoptic data.

IRLS will operate in the 400-mc frequency band, with satellite and sensor transmitter frequencies separated by about 40-50 mc. The equipment will use proven techniques and much of the hardware will be interchangeable.

- **Satellite package**—The gear going aboard the satellite, which will be placed in a near-polar orbit of about 600 mi. possibly in late 1967, is contained in a 12 x 6 x 6.5-in. package which includes the transmitter, diplexer, receiver, PCM encoder and synch demodulator, and a magnetic core memory for single-orbit data storage on-board. The system will use the *Nimbus* antenna and radiate 25 watts. The digital PCM subsystem will be able to transmit 1,000 12-bit words (eight data bits and four synch bits) per second to the receiving station.

The package aboard *Nimbus*, which will mount to the satellite's sensor ring, will interrogate the sensors, whose locations will be known to within certain limits, on pre-programmed command by means of a coded address system unique to each sensor. The satellite's antenna puts out a broad beam signal covering an area of more than 1,000 mi. on the ground, according to engineers here.

The satellite and sensor platform are also designed to perform a ranging function once the sensor is addressed in order to pinpoint the locations. In cases where the sensor may be moving, the more precise range data allows more accurate tracking information for command purposes; on subsequent orbits, it will be easier to instruct the satellite properly as to when to address the various sensors.

- **Smaller for sensors**—The sensors will be equipped with a package that is similar but smaller, because no memory is required. The T/R experiment will be identical to the satellite's, as will the PCM unit and demodulator. The 6 x 6 x 6.5-in. sensor package will use a fixed, omnidirectional cross-dipole antenna. When queried by the satellite, the sensor will sample the desired conditions, encode this data and transmit it, completing the transmission in about 3 to 5 second, according to Radiation.

The ground station interface equipment uses the same memory T/R and PCM gear as is found elsewhere in the network and also includes a paper tape formater for the receiving station.

A breadboard version of the complete system will be delivered four months from the contract date, with flight hardware due 13 months later. The firm is supplying three satellite packages, six sensor equipments and two ground station interface units. Location and types of remote sensors reportedly have not yet been decided upon. ■

available now!

Titan III, the U.S. Air Force's standard space launch system delivering nearly 2.5-million pounds of thrust . . . handling payloads from over ten tons for a 200-mile earth orbit to two-and-one-half tons for a moon shot . . . mission flexibility ranging from the orbiting of multiple satellites to boosting a complete manned laboratory into orbit. Cost effective. Man rated. Reliable. Even while it is still in R&D, Titan III is launching functional payloads—36 assigned to date.

Got a space mission? Get the facts
Titan III. Write on your letterhead
Dept. RC-400, Martin Company, Frien
ship International Airport 40, Marylan

MARTIN

The Industry Week

Mergers and Acquisitions

Scientific Data Systems, Inc., Santa Monica, Calif., electronic equipment and computer manufacturer, has acquired Consolidated Systems Corp. of Pomona, Calif. CSC makes data systems and is owned jointly by Allis-Chalmers Manufacturing Co. and Consolidated Electrodynamics, a Bell & Howell Co. subsidiary. Cost of the acquisition was not revealed. . . . *Cal/Val Research and Development Corp., Burbank, Calif., a subsidiary of the Maremont Corp. of Chicago, has acquired Fargo Rubber Corp. of Los Angeles. The acquisition is intended to complete Cal/Val's manufacturing and production facilities. Cal/Val's Isomode Div. makes vibration-control devices for use in mounting small motors and electronic instrumentation.* . . . Andersen Laboratories, Inc., West Hartford, Conn., has purchased the Delay Line Div. of Richard D. Brew and Co., Inc., Concord, N.H. The acquisition is said to provide Andersen Labs with additional advanced technology in dispersive and non-dispersive strip lines, solid delay lines and lumped constant lines. Andersen's series of dispersive strip lines will be complemented by Brew developments in low-frequency wide-band tapered strips. Also, Brew's work in non-dispersive coiled strip lines is seen as rounding out Andersen's digital delay line offering and the nanosecond lumped constant product group will broaden the company's electromagnetic line market coverage. . . . *Alcar Instruments, Inc., Trenton, N.J., which recently merged with the Ultrasonics Div. of General Instrument Corp., has decided to retain the complete ultrasonics cleaning lines of both of the companies. The decision is aimed at providing industry with a broad line of ultrasonic tanks, and a choice of magnetostrictive or piezoelectric transducers.* . . . Seegers Manufacturing Co. is the name given the merged organizations of Seegers Manufacturing Co., Seegers Building Corp., International Instruments, Inc., and Seegers Instrument Co., all located in Barrington, Ill. The merger was made to better coordinate the manufacturing, sales and advertising activities of the original firms.

New Activities

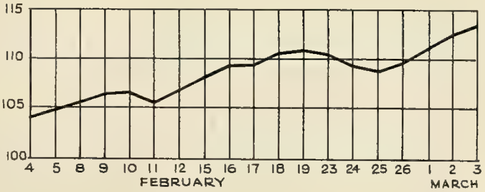
Lowry-Cocroft Abstracts, Evanston, Ill., has inaugurated a new abstracting service to provide coverage of new developments in the field of microelectronics. The service is to be comprehensive, covering the world literature and including every phase of microelectronics from the highly theoretical to the practical. The abstracts will be edited by Dr. Robert Pasek, the editor of Lowry-Cocroft's Laser Abstracts. . . . *Coors Porcelain Co., Golden, Colo., has established a Spectro-Chemical Laboratory for chemical and non-destructive testing services to industry. The facility will consist of a large chemical laboratory, containing spectrographic equipment, complete fluorescent and diffraction x-ray electron microscope and metallographic, particle size and surface area determination apparatae.* . . . Air Reduction Co.'s Air Reduction Sales Co. has been reorganized into four separate and specialized divisions, Airco Industrial Gases Div., Airco Welding Products Div., Airco Distributor Products Div. and Hofman-Paul Cryogenic Div. . . . *Haveg Industries, Inc., Wilmington, Del., has changed the name of its Winooski, Vt., subsidiary from American Super-Temperature Wires, Inc., to Haveg/Super-Temperature Wires, Inc. The firm makes high-temperature wire and cable for the electronic, aircraft, missile and computer industries.* . . . Borg-Warner Corp., Chicago, has formed a combined engineering, manufacturing and sales department to be known as Borg-Warner Thermoelectrics, to be housed at the B-W research center in Des Plaines, Ill. The department will continue the work in thermoelectrics formerly performed by the Pesco Products Div., Bedford, Ohio. . . . *The University of Texas, Texas A&M University, Rice University, University of Houston, Southern Methodist University, Louisiana State University and Florida State University has joined with Southwest Research Institute of San Antonio in a cooperative program whose first project will be the building and operation of a marine sciences research center to exploit the oceanographic potential of the Gulf of Mexico and its contiguous waters.*

New Facilities

Douglas Aircraft Co., Inc., will break ground this week for its $2-million, 46,000-sq.-ft. corporate advance research lab at Huntington Beach, Calif.

Missile/Space Stock Index

Viet Nam continued to be the one overall influencing factor in the behavior of the Missile/Space Stock Index. The monitored stocks dipped slightly with talk of possible negotiations on Viet Nam, but strengthened again with the release of the State Department White Paper and increased military retaliation in the area. Individual stocks were stimulated with the award of the *MOL* study contracts (p. 10), Thiokol's successful solid motor firing (p. 16), and the *Poseidon* contract award (p. 10).



STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

MISSILES AND ROCKET

HIRD ANNUAL DOD ISSUE, March 29, 1965

advanced technology and the DOD

Advanced Technology is the key to growth n the future. The March 29 issue of MISSILES AND ROCKETS will concentrate on the applications of advanced technology to actical warfare. It will encompass all phases of advanced technology for which the Defense and Space Industries have a unique capability and for which the DOD has unique requirements.

This issue will cover:

Advanced Technology: materials, electronics, power sources and basic research

Systems: combat support, air defense, command and control, mobility, and counter-insurgency

Plus these valuable guides:

Complete organization charts, procurement contacts and all defense level organizations involved in tactical warfare including DDR&E and ARPA.

Your advertising will have greater impact, greater importance and greater readership among the men making the important buying decisions in the military and industry.

PLAN NOW TO CAPITALIZE ON THIS UNIQUE EDITORIAL ATMOSPHERE.

M/R

Advertising Closes: March 15, 1965

Issue Date: March 29, 1965

AWARDS

AIR FORCE

$27,000,000—**Westinghouse Electric Corp.**, Bedford, Mass., for communications equipment.

$3,449,400—**Thiokol Chemical Corp.**, Promontory, Utah, for *Genie* rocket motors.

$2,434,000—**Communication Systems, Inc.**, Paramus, N.J., for a design study of a defense communications system.

$2,074,820—**American Electric, Inc.**, Paramont, Calif., to make unspecified ordnance.

$1,500,000—**Electronic Specialty Co.**, Los Angeles, for the design of a unique piece of associated ground equipment for a new reconnaissance system.

$1,500,000—**General Dynamics Corp.**, San Diego, for modification of *Atlas* missiles.

$1,375,000—**Burroughs Corp.**, Paoli, Pa., for radar maintenance sets.

$1,282,390—**Bendix Corp.**, Owings Mills, Md., for modernization of radar equipment.

$1,235,000—**Bunker-Ramo Corp.**, Canoga Park, Calif., for visual analysis display system.

$312,000—**Crest Ultrasonics Corp.**, Trenton, N.J., for production quantities of ultrasonic cleaning equipment.

$250,000—**E. I. DuPont de Nemours and Co.**, Wilmington, Del., for development and test of high energy fluorine containing solid propellant.

$183,665—**TRW/Space Technology Laboratories**, Redondo Beach, Calif., for engineering services in support of *Titan II* operational targeting program.

$150,000—**Massachusetts Institute of Technology**, Cambridge, Mass., for research of new concepts of energy conversion.

$149,982—**New York University**, New York City, for research on boundary layer characteristics for hypersonic flow in the presence of mass additions.

$138,000—**Douglas Aircraft Co.**, Missile and Space Systems Div., Santa Monica, Calif., for service engineering in support of program 437 airframe, AGE, telemetry, targeting and data reduction.

$58,000—**University of Texas**, Austin, for research on relativity and gravitational theories.

$30,000—**Lockheed Missile and Space Co.**, Sunnyvale, Calif., for research on improved high modulus, high strength filaments and composites thereof.

ITT Federal Laboratories, Aeronautical Systems Div., Nutley, N.J., to furnish two prototype units of new microminiature electronic navigation equipment (amount not disclosed).

Electro-Mechanical Research, Inc., Sarasota Div., Sarasota, Fla., for the development of a rocket-borne ultraviolet scanning spectrometer and photometer system (amount not disclosed).

Socony Mobil Oil Company, Inc., New York City, for a special program of research into plasmas (amount not disclosed).

ARMY

$46,585,000—**Morrison-Knudsen Company, Inc.**, Boise, Idaho, for construction of underground launching facilities for 50 *Minuteman* missiles in north central Montana.

$7,663,284—**Eastman Kodak Co.**, Kingsport, Tenn., for propellants.

$7,500,000—**General Telephone & Electronics Corp.**, Sylvania Electric Products Inc., Needham, Mass., for the production of advanced electronic communication equipment.

$3,518,719—**Chamberlain Corp.**, Scranton, Pa., for eight-inch projectiles.

$903,000—**Northrop Corp.**, Ventura Div., Beverly Hills, Calif., for continued production of the AQM-38A target missile.

$500,000—**Philco Corp.**, Aeronutronic Div., Newport Beach, Calif., for research and development in connection with *Chaparral* Air Defense System.

$307,000—**Varian Associates**, Palo Alto, Calif., for high powered klystrons for *Hawk* missile system.

$170,000—**Radio Corp. of America**, Communications Systems Div., Camden, N.J., increase in contract for a classified program.

$158,500—**H. J. High Construction Co.**, Orlando, Fla., for modifications to a support building in the spacecraft Fluid Test Complex to provide a clean room; also $52,760 for alterations to the Manned Spacecraft Operation Building in connection with manned *Apollo* program.

$124,661—**Stanford University**, Stanford, Calif., for linear decision technique for discrimination study for the *Nike-X* missile system.

$98,544—**Washington Engineering Service Co.**, Kensington, Md., for review and verification of format of *Lance* documentation.

$66,546—**Raytheon Co.**, Andover, Mass., for repair parts for *Hawk*.

$57,654—**D. Brown Associates, Inc.**, Eau Gallie, Fla., for research in geodetic secor ranging system.

$55,000—**Martin Marietta Corp.**, Orlando, Fla., for *Sprint* thrust vector control hardware system and engineering liaison.

Okland Construction Co., Salt Lake City, Utah, for *Minuteman* engineering test facility, Hill AFB, Utah (amount not disclosed).

NAVY

$5,962,000—**Maxson Electronics Corp.**, Great River, N.Y., for production of *Bullpup* missile components.

$4,957,584—**Avco Corp.**, Richmond, Ind., for production of arming and fusing devices for *Polaris* missiles.

$2,506,345—**Raytheon Co.**, Bedford, Mass., to investigate, develop and test means of achieving missile and overall system reliability for *Sparrow II*.

$2,307,379—**Sparton Corp.**, Jackson, Mich., for production of ASW sonobuoys.

$1,150,000—**Sperry Rand Corp.**, Long Island City, N.Y., for engineering work in connection with modification of *Terrier* and *Tartar* air defense missile computers.

$970,000—**Radio Corp. of America**, Communications Systems Div., Camden, N.J. for classified programs.

$732,000—**Hughes Aircraft Co.**, Los Angeles, to prepare proposals for production of *Walleye* TV-guided air-to-surface glide bomb.

$544,174—**Radio Corp. of America**, Princeton, N.J., for *Polaris* communications study.

$500,000—**Cooke Engineering Co.**, Alexandria, Va., for field engineering services in connection with the *Polaris missile* program.

$220,862—**General Dynamics/Pomona Div.**, Pomona, Calif., for *Terrier* and *Tartar* replacement parts.

$88,033—**Radio Corp. of America**, Missile & Surface Radar Div., Moorestown, N.J., for a classified program.

$49,545—**General Dynamics/Pomona Div.**, Pomona, Calif., for replacement parts for *Terrier* and *Tartar* missiles.

$36,360—**Lockheed Aircraft Corp.**, Missile & Space Co., Sunnyvale, Calif., for weapons system study.

$33,007—**Consolidated Electrodynamics**, Pasadena, Calif., for UK *Polaris* digitest instrumentation equipment repair parts.

NASA

$2,740,000—**Collins Radio Co.**, Dallas, to integrate electronic systems and three 85-ft. dish antennas into ground tracking and data acquisition stations in support of the *Apollo* program.

$1,198,923—**American Machine and Foundry Co.**, York, Pa., for umbilical devices used in servicing the *Saturn V* launch vehicle.

$1,256,000—**Aerojet-General Corp.**, Covina, Calif., for installation of instrumentation and control systems for ground firing tests of propulsion stages for *Saturn V*.

$1,138,872—**Greenhut Construction Co.**, Pensacola, Fla., for constructing an addition to a ground support equipment test facility at Marshall Space Flight Center, Huntsville, Ala.

$991,796—**Harvard College**, Cambridge, Mass., for study and experiment for a high resolution ultraviolet telescope and spectrometer system for *AOSO*.

$745,601—**Kaiser Aluminum and Chemical Sales**, Bristol, R.I., for the fabrication of bulk electrical cable for Complex 39, Kennedy Space Flight Center.

$596,356—**Spaco Inc.**, Huntsville, Ala., to fabricate interconnect cables for joining terminal boards in the umbilical towers of Complexes 34, 37 and 39 at Kennedy Space Flight Center.

$277,651—**Motorola Inc.**, Scottsdale, Ariz., for S-band transponders and test sets.

$193,000—**Electro-Optical Systems, Inc.**, Pasadena, Calif., for development and testing of porous ionizer materials.

$120,000—**Ohio State University**, Columbus, to experiment with radar as a means to explore the surface of the Earth from orbiting satellites.

$100,000—**University of Minnesota**, Minneapolis, for the establishment of a Technical Utilization Program.

$95,719—**Space-General Corp.**, El Monte, Calif., for a study of the application of advanced solid and hybrid propellant systems to space missions.

$87,000—**Avco Corp.**, Tulsa Div., Tulsa, Okla., to evaluate materials used as thermal coatings for outside surfaces of spacecraft.

$58,500—**Booz-Allen Applied Research**, Bethesda, Md., for study and experiment of the *OAO* spacecraft.

$44,205—**Stanford Research Institute**, Menlo Park, Calif., for investigation of satellite radiation and heat balance.

$39,100—**University of Illinois,** Urbana, for analytical investigations of the flow mechanism in ejectros and thrust augmentation devices.

$36,771—**Arde Portland, Inc.,** Paramus, N.J., for test rocket nozzles.

Electro-Mechanical Research, Inc., Sarasota Div., Sarasota, Fla., to develop and produce telemetry transmitters of advanced design (amount not disclosed).

INDUSTRY

$2,900,000—**HITCO,** Gardena, Calif., from **United Technology Center,** Sunnyvale, Calif., for design changes to *Titan III-C* rocket motor throat section.

$500,000—**Radio Corp. of America,** New York City, from **The Boeing Co.,** Seattle, to supply kits for modernization of the command network electronic equipment at Vandenburg AFB, Calif.

$350,000—**Radio Corp. of America,** New York City, from **The Boeing Co.,** Seattle, for classified electronic equipment.

$155,000—**Radio Corp. of America,** Missile & Surface Radar Div., Moorestown, N.J., from **Massachusetts Institute of Technology,** Cambridge, an increase in contract for the PRESS program.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Va.

Langley Research Center is negotiating a contract with the Martin Co.'s Space Systems Division for the performance of a conceptual study of a deep space meteroid satellite to be launched by a *Saturn-Centaur* vehicle. This notice is for information only; RFP not available.

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

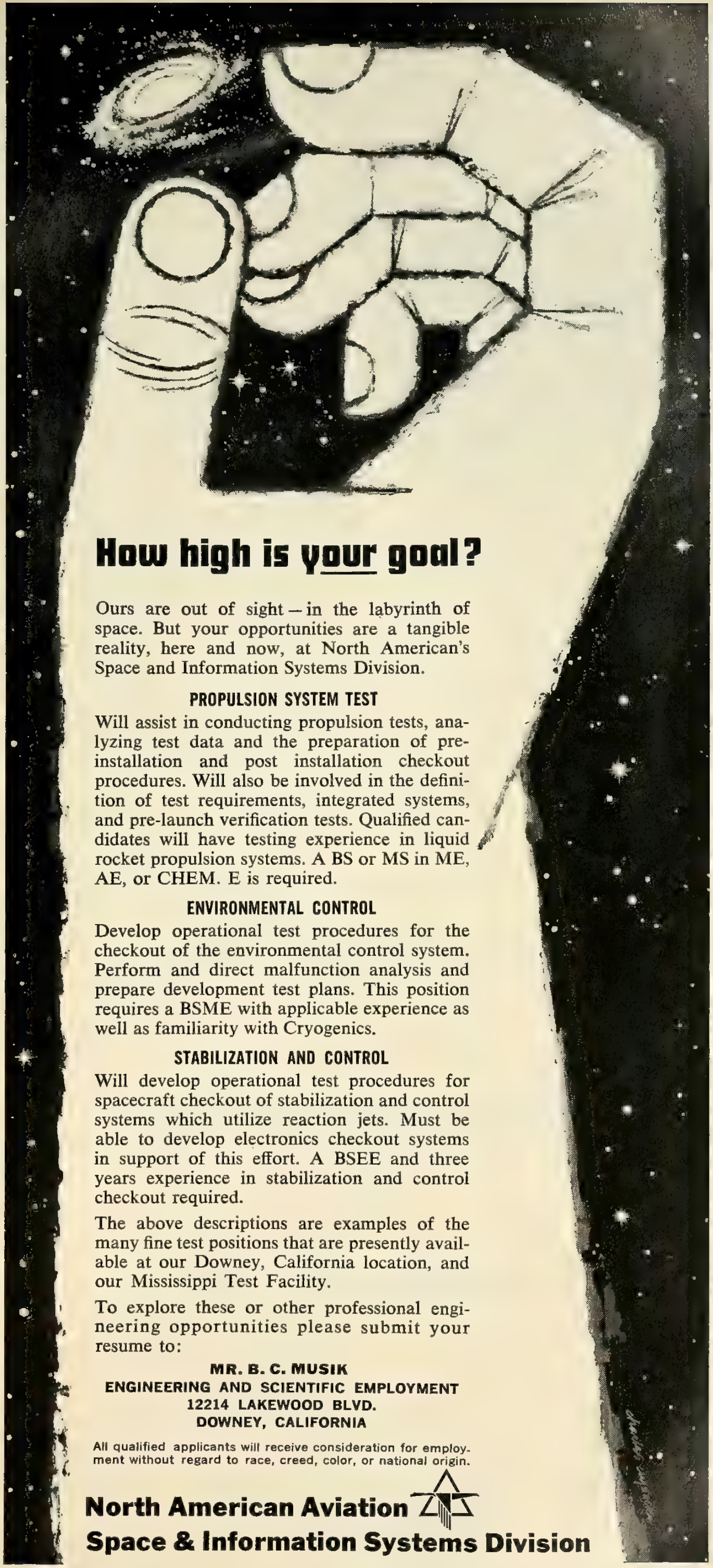
Negotiations are being conducted with Physics Technology Laboratories, Inc. for a continuation of the development and fabrication of an RF ion mass spectrometer calibration ion source system. This notice is for information only; RFP not available.

Bureau of Naval Weapons
Washington, D.C. 20360

The Bureau of Naval Weapons intends to solicit a proposal from Hughes Aircraft Company for a research and development study to determine the feasibility of incorporating a triad capability in the AN/ASG-9 (*Phoenix*) AMCS, and for preparation of engineering report. This notice is for information only; RFP not available.

Procurement and Production
R&D Contracts Division
Laurence G. Hanscom Field
Bedford, Massachusetts 01731

Negotiations will be conducted with Adcole Corp. for research directed toward design, development, construction and installation of rockets probe instrumentation. This notice is for information only; RFP not available.



How high is your goal?

Ours are out of sight — in the labyrinth of space. But your opportunities are a tangible reality, here and now, at North American's Space and Information Systems Division.

PROPULSION SYSTEM TEST

Will assist in conducting propulsion tests, analyzing test data and the preparation of pre-installation and post installation checkout procedures. Will also be involved in the definition of test requirements, integrated systems, and pre-launch verification tests. Qualified candidates will have testing experience in liquid rocket propulsion systems. A BS or MS in ME, AE, or CHEM. E is required.

ENVIRONMENTAL CONTROL

Develop operational test procedures for the checkout of the environmental control system. Perform and direct malfunction analysis and prepare development test plans. This position requires a BSME with applicable experience as well as familiarity with Cryogenics.

STABILIZATION AND CONTROL

Will develop operational test procedures for spacecraft checkout of stabilization and control systems which utilize reaction jets. Must be able to develop electronics checkout systems in support of this effort. A BSEE and three years experience in stabilization and control checkout required.

The above descriptions are examples of the many fine test positions that are presently available at our Downey, California location, and our Mississippi Test Facility.

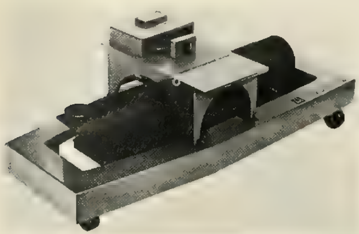
To explore these or other professional engineering opportunities please submit your resume to:

MR. B. C. MUSIK
ENGINEERING AND SCIENTIFIC EMPLOYMENT
12214 LAKEWOOD BLVD.
DOWNEY, CALIFORNIA

All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

North American Aviation
Space & Information Systems Division

New Product of the Week: Photographic Tester



A dynamic photographic tester, combining means of testing aerial cameras dynamically for focus, resolution, image motion, compensation and automatic exposure control, has been developed by Aeroflex Laboratories, Inc.

The device can test panoramic, strip, frame, mapping and other types of aerial cameras with focal lengths to 24 in. and film sizes of 16, 35 and 70 mm. and 5 in. Testers for cameras of larger specifications can be supplied.

The instrument features resolution to 100 lines/mm. and image motion compensation rates to 80 in./sec. with accuracies of 0.2% or better. Automatic electronic control provides full photographic light ranges at calibrated increments.

Circle No. 151 on Subscriber Service Card

Signal Sampler

A signal sampling device for RF and microwave circuits is available from Telonic Engineering Co.

The Model TSS-1 covers all frequencies through X-band and is basically an RF "T" connector with a movable leg. Capacitance between the signal line and sample line is varied by moving the leg toward or away from the main line. Coupling is adjustable from less than 10 db to over 40 db. Main line VSWR depends on the degree of coupling—coupling of 10 db results in a typical VSWR of 1.3:1 or less; with 30-db coupling VSWR is 1.15:1 or less.

Circle No. 152 on Subscriber Service Card

Mv-Controlled Oscillator

A millivolt-controlled telemetry subcarrier oscillator, capable of operation at frequencies between 300 cps and 1.6 mc and deviations of up to ±40%, has been announced by Electro-Mechanical Research, Inc.

The Model 237 is available for use in proportional-bandwidth and constant-bandwidth FM/FM telemetering systems. Plug-in channel selectors determine operating frequency and deviation; channel selectors for standard IRIG frequencies are available.

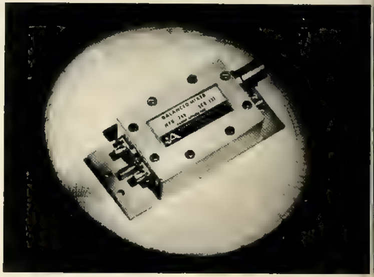
Design features include: conversion linearity (millivolts to frequency) with 0.05% of full bandwidth; 100-db rejection of common-mode signals as great as ±60v; 100-megohms input impedance; 20-microvolt rms equivalent input noise. It can be driven to full-scale deviation by inputs in the range of ±4 millivolts to ±1.6v.

Circle No. 153 on Subscriber Service Card

UHF Balanced Mixers

A series of miniature UHF broadband balanced mixers, constructed to meet MIL-E-5400 and MIL-I-6181 specifications, is available from Anzac Electronics, Inc.

Four models cover frequency ranges of 65 to 155 mc, 150 to 270 mc, 260 to 465 mc and 450 to 850 mc. L.O. power requirement is 0.5 mw. Typical noise figures are 7 db and typical VSWR on all ports is 1.5. IF is 60 mc.



Circle No. 154 on Subscriber Service Card

Testing Unit

Instron Corp. has introduced a universal testing instrument, suitable for testing both tension and compression. Designated the Model TT-B, it has a rated capacity of 20,000 lbs.

The device features a new crosshead guidance system which helps maintain horizontal and lateral stiffness at the higher ranges. Also, an electronic calibration circuit is incorporated to simplify calibration, making it unnecessary to calibrate routinely with dead weights.

Circle No. 155 on Subscriber Service Card

What's the shortest distance between these 2 points?

Los Angeles — Cape Kennedy
San Diego — Houston — New Orleans — Melbourne

National's direct line.

We call it our "Rocket Run." It's the only direct jet service between the major space centers of the west and Melbourne (closest airport to Cape Kennedy.)

You jet between Los Angeles and Melbourne without changing planes. National also serves the key space age cities along the east coast.

Is this any way to run an airline? You bet it is.

Jet National
coast to coast to coast

Circle No. 8 on Subscriber Service Card

Video Amplifier

A wideband video amplifier, providing pulse and sine wave capability for space communications, ground support, data acquisition and other applications, is being marketed by Conductron Corp.

The miniaturized Vidamite C-401 has a bandwidth of 60 cps to 200 mc. Gain is 30 db nominal with 40 to 60 db optional. Gain flatness is ±0.5 db. The device has an input impedance of 50 ohms, output impedance of 100 ohms, and noise less than 40 μv equivalent input.

Circle No. 156 on Subscriber Service Card

Ultrasonic Hardness Tester

Branson Instruments, Inc., is marketing an ultrasonic hardness tester that is nondestructive, portable and direct reading.

The Model 100 uses an electromechanical principle and does not require optics, high-pressure contact or impact to produce a measurement. In operation, a probe, which can be hand-held or mechanically clamped, is brought into contact with the work surface. The instrument can be calibrated to read directly in any hardness scale in common use, eliminating the need for chart conversion. The scale can be expanded around any selected point to increase the readability. One reading every 3 seconds can be made with an accuracy of ±1 on the Rockwell "C" scale.

Circle No. 157 on Subscriber Service Card

Amplifier

Nexus Research Laboratory, Inc., is marketing a 60-v operational amplifier, the SA-60, available in a compact encapsulated package.

The package configuration permits use in environments where high shock, vibration of humidity may be encountered, the firm says. Electrical characteristics include a supply voltage of ± 75v; supply current of ± 25 ma; open-loop gain at dc of 100,000 min. Operating temperature range is −25° to 55°C. Equivalent input noise voltage is 6 μv RMS typical.

Circle No. 158 on Subscriber Service Card

PRACTICAL
PERT
$3.75
Including CRITICAL PATH METHOD
B. J. HANSEN
A STEP-BY-STEP GUIDE
How to use today's foremost management tool to increase profits and industrial efficiency
AMERICA HOUSE

FOR ALL LEVELS OF MANAGEMENT

2nd Big Printing!

$3.75

by B. J. HANSEN

(member of the original Polaris-PERT Team)

You get the complete **PERT** system and, for the first time, a **PERT** technique showing you how to predict and monitor profit on a continuing bi-weekly cycle.

Chapter XII, "Profit **PERT** and Incentives," brings you the Martin Company case history showing how the Titan III **PERT**-profit system works: In the words of Secretary of Defense Robert McNamara, "(Titan III) is probably the best managed contract we have, and it is the best managed almost entirely because of the tremendous incentive given to that contractor in the form of potential profit increases to hold his costs down."

PRACTICAL PERT tells how and when to meet contract obligations, how to keep programs on schedule, how to win highest incentive fees. **PERT**, developed for the nation's defense programs, can be applied to management operations to monitor profit as well as cost, time and performance in the fields of construction, chemical processing, manufacturing . . . and wherever complex systems are involved.

PRACTICAL PERT contents

I INTRODUCTION TO PERT
II THE ABC'S OF PERT
III PERT & TIME
IV HOW PERT PLANS
V HOW PERT CONTROLS
VI BUILDING PERT
VII WHAT IS NETWORKING
VIII REFINING THE NETWORK
IX MEASURING MANAGEMENT RISK
X PERT & COST
XI PERT COSTS & COMPUTERS
XII PROFIT PERT & INCENTIVES
XIII PERT DATA DISPLAY

AMERICA HOUSE
Dept. A
1001 Vermont Avenue, N.W., Washington, D.C. 20005

Send Me ☐ Copies of Practical Pert $3.75 .25c Handling $4.00

☐ Check Enclosed ☐ Bill Me

Name .... Job/Title ....

Address .... City .... ☐ HOME? ☐ BUSINESS?

Zip Code .... State .... Co. Name ....

MOVING?

let us move with you!

**Six Weeks Is Required
To Change Your Magazine Address**

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, if possible, the address label from your last issue . . . include your postal ZIP number. Thank you.

Write to:

**Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005**

◆ ◆ ◆

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Paris, France—11 Rue Condorcet; TRU 15-39

names in the news

DAVIS

RECKTENWALD

DRAKE

PATTERSON

Richard J. Davis: Appointed vice president-public relations for Douglas Aircraft Co. He was formerly public relations representative for the company in Washington, D.C., after having been with *Newsweek* for 18 years.

Richard M. Recktenwald: Elected a vice president of The Electrada Corp. He will continue in his position of general manager of the Airite Products Div.

Robert F. Drake: Promoted to vice president and general manager of the Huyck Corp.'s new Metals Co. division. Also promoted at the same time was **Robert J. Demartini** to group vice president-military products of the new products and corporate research group.

William C. Patterson: Appointed vice president for government relations of the Harris ASW Div. of General Instrument Corp. He was formerly manager of the Washington office of Packard Bell Electronics Corp.

Elmer A. Sticco: Appointed group vice president-mechanical group of Electronic Specialty Co. He was formerly general manager of the company's Connecticut Div.

Richard D. Coons: Elected to the newly established position of executive vice president of GCA Corp. He was formerly a vice president and general manager of the GCA Technology Div. **Louis L. Frank** was appointed to replace Coons.

L. Edwin Smart Jr and Robert W. Purcell: Elected to the board of directors of The Bendix Corp. Smart is vice president-international operations and Purcell is chairman of the International Basic Economy Corp.

Robert B. Gilruth: Awarded the 1964 "Spirit of St. Louis Medal" for his outstanding service to aviation in the formulation of aircraft performance standards, development of pilotless aircraft, and in directing the successful evolution of the Project *Mercury* Earth-orbital manned spacecraft. He is director of NASA's Manned Spacecraft Center in Houston.

Paul R. Dolan: Became president of Eldon Fiberglass Manufacturing Co. in a series of changes in the firm's organizational structure. He was formerly president of Micro-Systems, Inc. Also involved in the reorganization were **Darrel E. Francy,** now vice president-marketing; **Robert D. Koontz,** manager of new products; **Ben Gerson,** manager of materiel; and **Richard I. Guerena,** manager of administration.

David P. Mason: Elected president of Testing Systems, Inc., manufacturer of non-destructive testing equipment. He was formerly with Magnaflux Corp.

Lockheed Propulsion Co. has named a special task force which has responsibility for the company's work on the *Short Range Attack Missile (SRAM)*. **Warren F. Westermeier** is vice president-*SRAM*, with overall cognizance of the work presently being performed. **John O. Crouch** is program manager of two technology programs sponsored by Rocket Propulsion Laboratory, AFSC, as well as being right-hand man for Westermeier. Other members of the task force include: **Neal Lardy,** project engineer; **Grady Hall,** product assurance; **Dr. L. D. Smoot,** engineering research; **Penn Holter,** operations; **Arvid Wahlquist,** systems integration; **Kenneth Miller,** procurement; **Walter Baron,** contract administration; and **J. A. Richards,** schedule and cost control.

John J. Connolly: Elected a vice president of Litton Industries, in charge of the components group. He succeeds **Harry J. Gray,** who has been appointed senior vice president-finance and administration. Succeeding Connolly is **C. Gordon Murphy,** who has become president of the Data Systems Div.

Hughes Aircraft Co. has made a series of promotions in its executive alignment and named five new vice presidents and a new secretary. **John W. Black,** formerly vice president and manager of the company's Aeronautical Systems Division, aerospace group, became assistant group executive. Succeeding him is **William F. Eicher. Dr. Fred P. Adler** was named a vice president, along with **Dr. Nicholas Yaru, Dr. Malcolm R. Currie** and **Dr. George F. Smith. Robert S. Killough** was named secretary of Hughes Aircraft Co.

James M. Maddock: Promoted to senior vice president of Dyna-Therm Corp. He has been with the company since 1954.

In order to continue its 156-in.-dia rocket motor work, Lockheed Propulsion Co. has organized a team to be headed by **Frank V. Genetti,** a veteran in large solid propellant motor work. Engineering manager will be **J. S. Coverdale;** his assistant will be **G. T. Oppliger.** Managers for manufacturing, procurement and test will be **F. E. Skovgard, K. Miller** and **T. P. Carpenter.**

—when and where

MARCH

Fifth International Symposium on High Speed Testing, sponsored by Massachusetts Institute of Technology and Brooklyn Polytechnic Institute, Sheraton Plaza Hotel, Boston, March 8-9.

Marine Systems and ASW Conference, sponsored by the AIAA and the Navy, San Diego, Calif., March 8-10.

West Coast Symposium on Arms Control, sponsored by the American Ordnance Assn. and TRW Space Technology Laboratories, Los Angeles, March 8-10.

ntegrated Circuit Engineering Management, Design and Applications Seminar, sponsored by the Integrated Circuit Engineering Corp., Phoenix, Ariz., March 8-12.

National East Coast Meeting of the International Committee of the Aerospace Industries Assn., International Inn, Washington, D.C., March 9-11.

Workshop Seminar in the Analysis of Viscoelastic Materials for Engineering Applications and Product Design, sponsored by the Plas-Tech Equipment Corp., Boston, March 10-12.

Particle Accelerator Conference, sponsored by the IEEE, Shoreham Hotel, Washington, D.C., March 10-12.

Man-in-Space Symposium, sponsored by the Louisiana Psychology Assn., NASA Michoud Operations, New Orleans, March 12.

Third Annual Conference on New Horizons on Quality and Reliability, sponsored by the IEEE, Harpus College, Binghamton, N.Y., March 13.

nternational Symposium of the Solar Energy Society, Phoenix, March 15-17.

Los Angeles Chamber of Commerce Aerospace Committee Meeting, Los Angeles, March 16.

Advanced Planning Briefings for Industry, sponsored by DOD and NSIA, Americana Hotel, New York City, March 16-17.

Aviation and Space Conference, sponsored by the American Society of Mechanical Engineers, Statler-Hilton Hotel, Los Angeles, March 16-18.

Third National Inter-Service Data Exchange Program (IDEP) Conference, sponsored by the IDEP Contractor Advisory Board, in conjunction with the Army, Navy, and Air Force, Albuquerque, N.M., March 16-18.

Spring Conference of the Electronic Industries Assn., Mayflower Hotel, Washington, D.C., March 16-19.

Second Annual Southeastern Symposium on Government Contracts, sponsored by the National Contract Management Assn., Ramada Inn, Cocoa Beach, Fla., March 18-19.

Third Goddard Memorial Symposium of the American Astronautical Society, Marriott Key Bridge Hotel, Washington, D.C., March 18-19.

nternational Convention of the IEEE, New York Hilton Hotel and New York Coliseum, New York City, March 22-25.

Second Microwave Symposium on Microwave Measurements, sponsored by Weischel Engineering, New York City, March 22-25.

Spring National Convention of the Society for Nondestructive Testing, Los Angeles, March 22-26.

22nd Annual Conference of the Western Section of the Society of the Plastics Industry, Hotel del Coronado, Coronado, Calif., March 24-26.

Convention of the American Society of Photogrammetry and the American Congress on Surveying and Mapping, Shoreham Hotel, Washington, D.C., March 28-April 3.

Seminar on Random Vibration, sponsored by MB Electronics, MB facility, New Haven, Conn., March 30-April 8.

Advanced Planning Briefings for Industry, sponsored by the DOD and NSIA, Conrad Hilton Hotel, Chicago, March 31-April 1.

Optical Society Meeting, Statler-Hilton Hotel, Dallas, March 31-April 2.

APRIL

IEEE Seminar on Space Vehicle Reliability, Airport Marina Hotel, Los Angeles, April 2.

Sixth Structures and Material Conference, sponsored by the AIAA, Riviera Hotel, Palm Springs, Calif., April 5-7.

International Symposium on Fission Product Release and Transport Under Accident Conditions, sponsored by the Oak Ridge National Laboratory, Oak Ridge, Tenn., April 5-7.

Symposium on High Energy Physics, sponsored by the Institute of Physics and the Physical Society (England), Birmingham, England, April 5-8.

International Symposium on Techniques of Memories, sponsored by the French Society of Electronics Technicians and Radioelectricians, Paris, April 5-10.

International Nuclear Exhibition and Conference, sponsored by the Institution of Nuclear Engineers, Brighton, England, April 5-10.

1965 Annual Region III Meeting of IEEE, Robert E. Lee Hotel, Winston-Salem, N.C., April 6-8.

Symposium on Advanced Propellant Chemistry, sponsored by AIAA and ACS, Detroit, Mich., April 5-7.

Third Navy Microelectronics Program Conference, U.S. Naval Postgraduate School, Monterey, Calif., April 5-7.

IEEE Computer Technology Conference, Thunderbird Hotel, Los Angeles, April 6-8.

1965 International Exhibition of Electronic Components and First International Exhibition of Audio Equipment, Paris April 8-13.

1965 Annual Region VI Conference of the IEEE, Las Vegas, Nev., April 13-16.

15th Annual National Telemetering Conference, sponsored by the IEEE, ISA and AIAA, Shamrock-Hilton Hotel, Houston, April 13-15.

Symposium on System Theory, sponsored by the Polytechnic Institute of Brooklyn, IEEE, Society for Industrial and Applied Mathematics, AFOSR, ONR and the Army Research Office, New York City, April 20-22.

Advertisers' Index

AEROJET-GENERAL CORP. 48
Agency—D'Arcy Adv. Co.

APPLIED PHYSICS LABORATORY, THE JOHN HOPKINS UNIVERSITY 6
Agency—S. G. Stackig, Inc.

ATLAS CHEMICAL INDUSTRIES, INC., AEROSPACE COMPONENTS DIV. 11
Agency—Harris D. McKinney, Inc.

AUTONETICS, DIV. OF NORTH AMERICAN AVIATION, INC. 32
Agency—Batten, Barton, Durstine & Osborn, Inc.

GENERAL ELECTRIC CO., APOLLO SUPPORT DEPT. 3
Agency—Deutsch & Shea, Inc.

MARTIN CO. 36
Agency—Ketchum, MacLeod & Grove, Inc.

NATIONAL AIRLINES, INC. 42
Agency—Kenyon & Eckhardt, Inc.

SCIENTIFIC DATA SYSTEMS 28
Agency—Faust/Day Adv.

SPACE & INFORMATION SYSTEMS, DIV. OF NORTH AMERICAN AVIATION, INC. 41
Agency—Batten, Barton, Durstine & Osborn, Inc.

SPACE TECHNOLOGY LABS, SUB. OF THOMPSON RAMO WOOLDRIDGE, INC. 8
Agency—Fuller & Smith & Ross, Inc.

SPERRY GYROSCOPE CO., DIV. OF SPERRY RAND CORP. 7
Agency—Reach, McClinton & Co., Inc.

THIOKOL CHEMICAL CORP. 2
Agency—MacManus, John & Adams, Inc.

VARIAN ASSOCIATES 47
Agency—Hoefer, Dieterich & Brown, Inc.

VITRO CORPORATION OF AMERICA ... 4
Agency—Buchen Adv., Inc.

CLASSIFIED

FOR SALE OR LEASE

5000 GALLON—53# W. P. DEWAR SUITABLE FOR OXYGEN, NITROGEN, OR HYDROGEN. AVAILABLE IMMEDIATELY.

NATIONAL ANNEALING BOX COMPANY
Washington, Pennsylvania

Top-Level Space Support

PRESIDENT JOHNSON'S recent surprise visit to National Aeronautics and Space Administration Headquarters in Washington was a welcome affirmation of his strong interest in the nation's space program.

The President, after a *Mariner* briefing, bestowed lavish praise on the *Mariner* team, the space agency and Administrator James Webb.

He also recalled that he had been the author of the 1958 Space Act establishing NASA, terming it "one of my proudest legislative accomplishments in 25 years in Congress."

"I feel somewhat close to this agency," the President declared.

This was the second strong display of Administration interest in the space program within a few days. Earlier, Vice President Humphrey visited Cape Kennedy for comprehensive briefings on the NASA and Air Force programs under way there. The Vice President, who by statute is also chairman of the National Aeronautics and Space Council, still has a lot to learn about space. Understandably, he is not yet familiar with the complex terminology of the Space Age.

The Vice President, however, has tackled his homework with characteristic vigor and bounce. He took in the MILA complex on Merritt Island, the Air Force's new *Titan III* complex and a number of blockhouses. He examined the *Gemini* spacecraft which now is mated to its *Titan II* launch vehicle for the manned *GT-3* flight. He listened attentively to detailed briefings.

The Vice President left the Cape admittedly awed by what he had seen there. He could not have chosen a better place to start his space education. The Cape today, with the *Titan III* complex nearing completion and the MILA construction well along, is enough to impress even the most experienced space experts.

The scale of the MILA complex, with its giant crawlers and mobile launch towers for *Saturn*, is unbelievable. Its sheer size seems almost a concrete expression of our determination to conquer space.

There is, at the same time, the sobering realization that we have gone just about as far up the scale of Earth-bound facilities as we can go. Anything larger will be almost technically impossible. The route for the future probably will be to assemble in orbit anything larger than can be handled in the *Saturn V/Apollo* facilities.

The MILA complex, nevertheless, is a good measure of the technological progress of this nation. A few years ago, for example, construction of the crawlers alone would have been beyond the bounds of the possible. Today, these mammoth objects fall into the role of support equipment for something that will be even more stupendous.

The Air Force's *Titan III* complex, while on a smaller scale than MILA, is impressive both from the standpoint of size and for the logic of its planning. But, once again, it is concrete evidence that there must be a limit to the size of practical launch vehicles.

IT IS PERHAPS WORTHWHILE in this context to re-examine what the President told Congress about future manned missions in his recent report on 1964 space activities.

"Studies of possible advanced manned missions conducted in 1964 gave increased evidence of the advisability of basing plans for the immediate future on the exploitation of the capabilities being created in the *Apollo* program," President Johnson said. He noted that beyond the *Gemini* and *Apollo* programs, three broad possibilities are being examined.

First, alternate and growth concepts within the present scope of these programs are being studied, looking among other things at use of the *Apollo* spacecraft for other Earth-orbital and lunar missions.

Second, those modifications of in-development hardware which appear logical are being examined. *Apollo*, for example, is capable of very long Earth-orbit missions if sufficient modification is provided.

Finally, studies are being carried on of those manned mission concepts which would require major new development areas.

The President noted that studies of future mission possibilities fall into three broad areas—Earth-orbital, lunar and planetary operations. He pointed out that in the area of lunar operations, possible activities identified beyond the basic *Apollo* mission include: exploration of the lunar surface in detail from lunar orbit or on the surface; establishment of semi-permanent or permanent bases and outposts for observations of the universe; and use of the resources of the Moon itself. In the area of planetary operations, mission analyses are being conducted to define an exploration program and to specify the early research and development needed for later systems.

In regard to launch vehicles, the President noted that it may be possible to provide even greater payload capability for the advanced missions by uprating the *Saturn IB* and *Saturn V* in a number of ways. In addition, there is study of the possibility that newer and more powerful launch vehicles may have to be developed for some of the advanced missions under consideration.

The President's future look at manned missions is a sensible one and an approach that the industry can support. Backed up by the interest he and his Vice President have recently displayed, it bodes well for U.S. goals in space.

William J. Coughlin

IEEE
VARIAN CENTER
2ND FLOOR

NEW!
Hybrid Amplifier
Greater bandwidth
Greater efficiency
Greater gain
In **one** microwave tube

NEW!
Reflex Klystron Oscillators

NEW!
UHF-TV Klystrons
High power klystrons for RCA 30-kW transmitters
8,000-hour guarantee

NEW!
Solid State
Varactors
Multipliers
Power Sources

NEW!
High Power
Low Power
Medium Power
Magnetrons

NEW!
BOPAC*
Custom Microwave Packages
Klystron/cavity and mixer/solid state power supply, in one ready-to-use package

NEW!
Millimeter Klystrons

NEW!
Light weight
Small size
Magnetically shielded
BWO's

NEW!
BETO* Bomac
Electronically
Tunable **O**scillators
Models L thru X band

NEW!
Crossed-Field Amplifiers

NEW!
UHF-TV TWT's
Longer life
More economy
Guaranteed
3,000 hours

NEW!
100-Watt TWT's
Octave tuning

Visit
LEL
Booths 2106 & 2108
2nd Floor
A new Varian Division

*Varian Trademark

VARIAN associates
TUBE GROUP

Executive Offices: 611 Hansen Way, Palo Alto 10, Calif. ☐ Microwave Tube Group: Palo Alto Tube Division ☐ Solid State Products ☐ Bomac Division ☐ SFD Laboratories, Inc. ☐ Varian Associates of Canada, Ltd. ☐ In Europe: Varian A.G., Zug, Switzerland

Circle No. 9 on Subscriber Service Card

5-SIGMA.

Now — pressure vessels move into the space age, Stage II.

Accelerator — Aerojet's revolutionary 5-SIGMA approach. A new concept of design, specification, control, and construction of metallic pressure vessels.

Major benefit — weight reductions up to 33%. With across-the-board applications wherever weight is of vital importance, such as propellant, fuel and oxidizer tankage, gas storage vessels, environmental system tankage.

5-SIGMA — a startling advance in the state of the art. Conceived, tested and proven by Aerojet, after a decade-plus of experience in the development and production of more than 27,000 pressure vessels for flight systems.

Investigate it.

AEROJET
GENERAL TIRE
GENERAL
TM

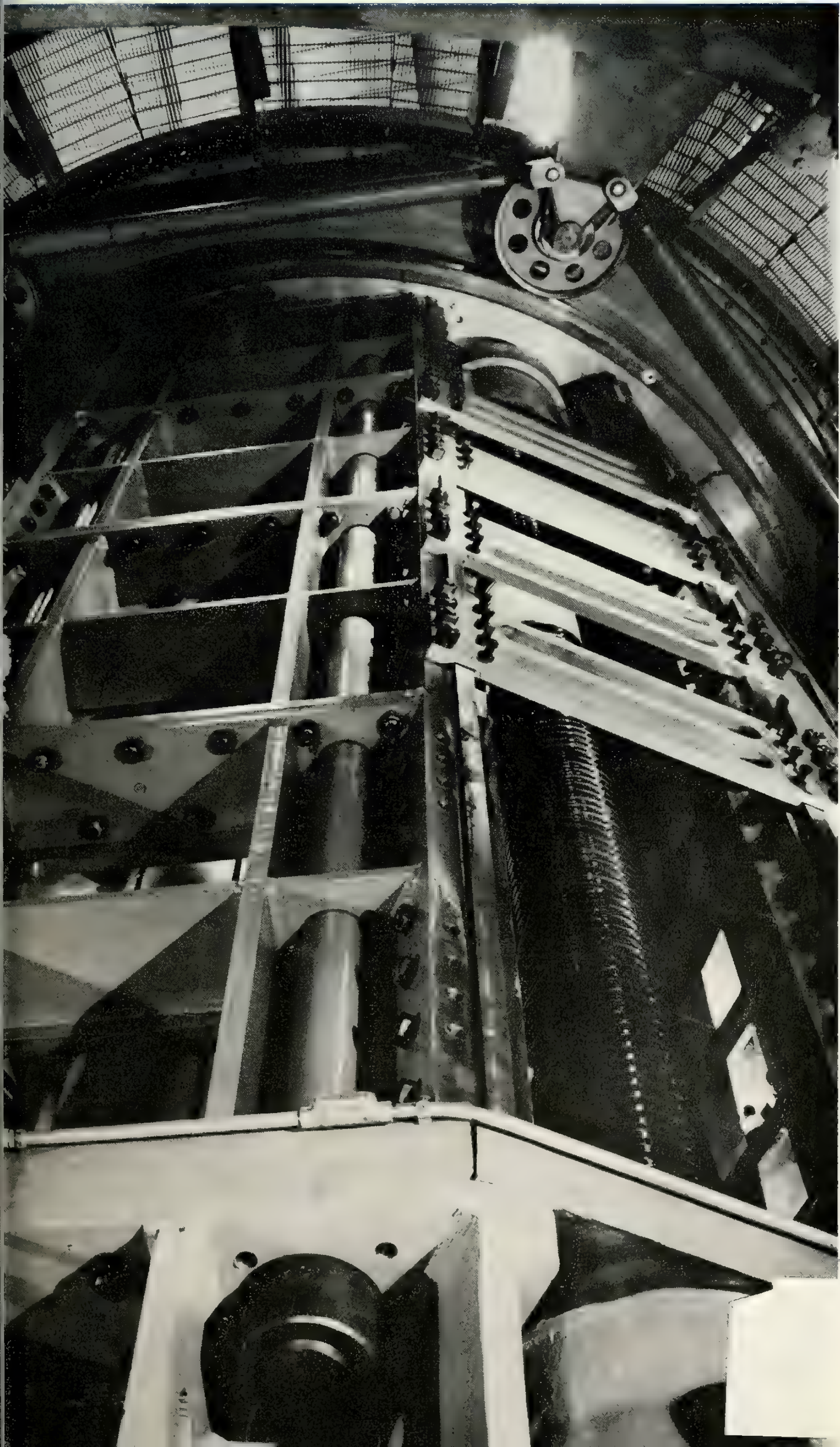
AEROJET-DOWNEY / WOODRUFF AVENUE
DOWNEY, CALIFORNIA

MARCH 15, 1965

missiles and rockets

HE WEEKLY OF ADVANCED TECHNOLOGY

MAR 1965
HOUSTON PUBLIC
LIBRARY
Houston, Texas



Flying Submersible Now Proven Feasible

Voyager To Avoid Surveyor Snags

Roll-Extruder Ideal for Motors

Building Delays Snarl MILA Plans

NTW's Unique and Massive Roll-Extrusion Machine

We dug and refilled a 4000-mile trench to protect 9300 communications circuits against disaster

We split the continent with a trench four feet deep to give the United States its first blast-resistant coast-to-coast underground communications cable system.

More than four years ago when the first of 2500 giant reels of coaxial cable started unrolling in New York State, we began an important project that will give added protection to the nation's vital communications.

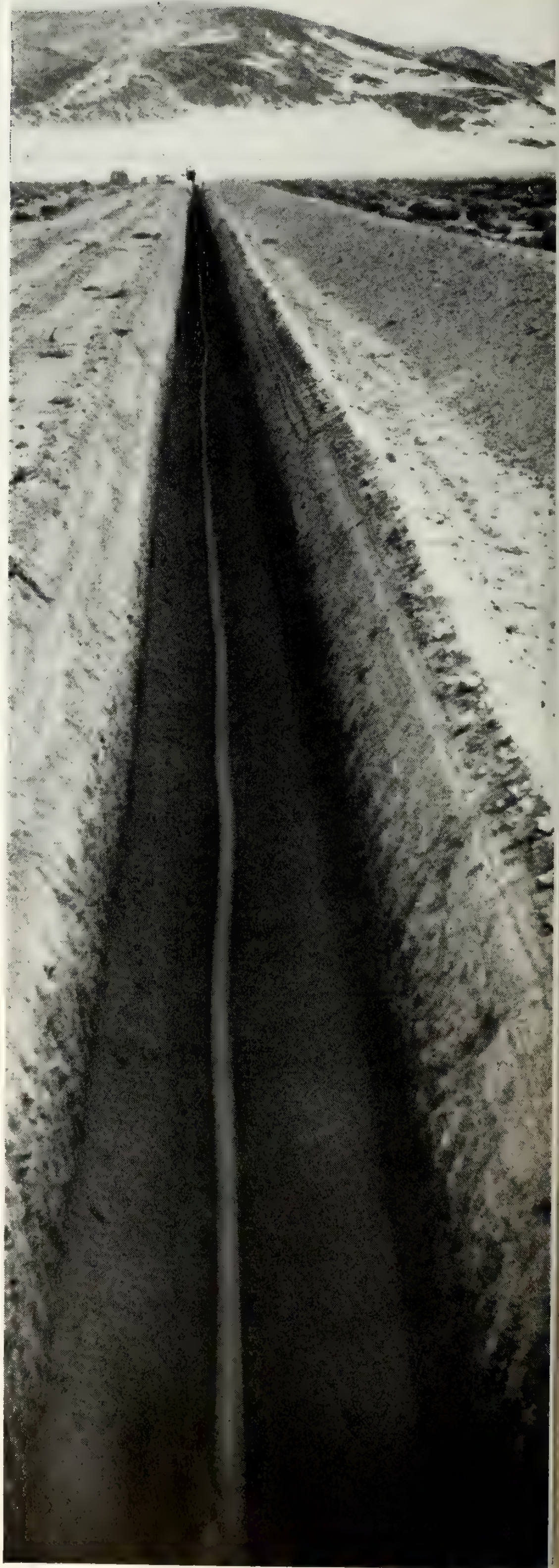
Today, 9300 circuits—available for voice, data, teletypewriter, telephoto—are included on this route. It stretches across 19 states and has 950 buried reinforced concrete repeater (or amplifying) stations.

Spotted strategically along the route about 50 feet below ground level are 11 manned test centers. Also of reinforced concrete, they have automatic air filtration and ventilation and living quarters stocked with emergency food and water.

This vital transcontinental link will serve the needs of government agencies, businesses and individuals.

This is a job that needed the Bell System's unified research, manufacturing and operating capabilities. It is another implementation of a basic Bell System policy: "In communications, the defense of the nation comes first."

Bell System
American Telephone and Telegraph Co.
and Associated Companies



missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 11 March 15, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors
harles D. LaFond.................Electronics
Villiam S. Beller.................Engineering

Associate Editors
awrence J. Curran......Assistant Managing Editor
eather M. David..................Space Medicine
ichael Getler........................Electronics
ohn F. Judge..................Propulsion/Materials
obert L. Parker.......................Copy Editor
ex Pay...............................Electronics
al Taylor...................................NASA
ames Trainor.............................Military
onald L. Zylstra.........................Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

riedrich Schonbach....................Art Director
onald Strickland............Assistant Art Director
uzanne Montgomery............Editorial Assistant
ally Fosnight....................Editorial Assistant

UREAUS
OS ANGELES.....9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks...................Bureau Chief
EW YORK.....................20 East 46th Street
Michael Getler
APE KENNEDY ....507 Orange Ave.
Merritt Is., Fla.
IDWEST ....423 N. Quentin
John L. Zimmerman ....Wichita, Kan.
ARIS..........................11 Rue Condorcet
Jean-Marie Riche

DITORIAL ADVISORY BOARD
r. Peter Castruccio Alexander Satin
onrad H. Hoeppner Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

. C. Boughton.............National Sales Manager
aul B. Kinney........Eastern Advertising Manager
dwin J. Denker, Jr.....Western Advertising Manager
enneth C. Blanchard.Marketing & Research Director
ohn N. Carlin..............Director of Circulation
addy Nelson................Circulation Promotion
. Virgil Parker..............Director of Production
arbara Wiener........Advertising Services Manager

ublished each Monday with the exception of the ast Monday in December by American Aviation ublications, Inc., 1001 Vermont Ave., N.W., Washngton, D.C. 20005. Cable Address: AMERAV.

rinted at Judd & Detweiler, Inc., Washington, D.C. econd class postage paid at Washington, D.C.

opyright 1965, American Aviation Publications, Inc.

ubscription rates: U.S. and Possessions, Canada, and an American Postal Union Nations: 1 year, $5.00, 2 ears $8.00, 3 years $10.00. All other foreign: 1 year 15.00, 2 years $25.00, 3 years $35.00. Air freight to urope: 1 year $20.00, 2 years $30.00, 3 years $40.00. ngle copy prices: regular issues 50 cents each; ecial issues $1.00 each. Subscriptions are solicited ly from persons with identifiable commercial or ofessional interests in the missile/space industry. bscription orders and changes of address should be eferred to Circulation Fulfillment Mgr., Missiles and ockets, 1001 Vermont Ave., N.W., Washington, .C. 20005. Allow 4 weeks for change to become fective and enclose recent address label if possible.

esident.........................Wayne W. Parrish
enior Vice President...............Louis C. James
ice President.......................Fred S. Hunter

THE COVER

View from bottom of 40-ft.-deep enclosure housing below-ground portion of NTW Missile Engineering, Inc.'s roll-extrusion machine. Facility can produce cylinders 160 in. in diameter and 20 ft. long, should have significant impact on rocket motor case fabrication. See story on p. 22.

MARCH 15 HEADLINES

$58.3 Million in MSFC Awards Go to Nine Firms 8
North American, Northrop Get Condor PDP Studies ... 8
Convair Study Concludes 'Flying Sub' Is Practical 12
Breakdown of Army FY '66 Missile Fund Request ... 13
Overruns Trigger NASA Need for Money Transfers .. 14
Voyager Plans Would Avoid Surveyor-Type Problems . 15
GT-3 Readied Amid Rumors of Pending Soviet Launch .. 16
NASA Wants To Reprogram $14 Million for Big Solids .. 17
Picture Report on Atlas-Centaur Mishap 18

ADVANCED MATERIALS®

Roll Extruder Should Be Boon to Motor Fabricators 22

SPACE SUPPORT

MILA Building Lag Hampers Launch Planners 26
Simulator Advances Stellar-Inertial Guidance Testing .. 28

SPACE MEDICINE

Drugs Simulate Astronaut Space Disorientation 33

SPACE ELECTRONICS

Computers To Aid Space Station Mission Studies 34

DEPARTMENTS

Letters 5
The Countdown 7
The Missile/Space Week® 8
Technical Coundown ... 21
The Industry Week 37
Contracts/Procurements 38
Products & Processes ... 40
Names in the News 44
When & Where 45
Editorial 46

47,500 copies this issue

LOOK AT LOCKHEED IN BIOASTRONAUTICS

Success in any manned aerospace or hydrospace venture depends greatly upon our ability to maintain the life of the crew over long periods, and upon their performance.

To provide Human Factors data essential in resolving these major problems which face the planners, designers and builders of future space vehicles, the Bioastronautics organization at Lockheed Missiles & Space Company has established a broad man-in-space simulation capability.

Utilizing the team that developed the multi-purpose AGENA booster/satellite and the POLARIS missile, Lockheed is clearly demonstrating its ability to cope with the many environments of *space*—within the ocean's depths as well as beyond earth's atmosphere.

Engineers & Scientists with advanced degrees and experience in Life support, Bioinstrumentation, Toxicology, Physiological and Experimental psychology, Altitude and Mission simulation, or Oceanology are invited to join this distinguished aerospace team.

Write for a brochure that will give yo
a more complete Look at Lockheed
Address: Lockheed Missiles & Spac
Company, Dept. 530, P.O. Box H504
Sunnyvale, California.

LOCKHEED
MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATIO

AN EQUAL OPPORTUNITY EMPLOYE

letters

Reason for Optimism

To the Editor:

This note is prompted by your March 3 editorial, "Top-Level Space Support."

Your piece expresses well the basis for optimism regarding the leadership of the national space program. By bringing together the recent visit of the President and Vice President to NASA, the trip of the latter to the Cape, and the statements in the President's Annual Report, you have given good support to your thesis. I compliment you on the editorial.

Edward C. Welsh
Executive Secretary
National Aeronautics
and Space Council
Washington, D. C.

Whither Ranger IX?

To the Editor:

I cannot agree with your editorial view ("An Unsolicited Proposal," M/R, March 1, p. 46) that *Ranger VIII* was a monumental waste. It met its objectives, and even though it showed pretty much what was expected—what if it had shown something totally unexpected?

Your "unsolicited proposal" for photographing the Earth would be interesting, but I am still for focusing on the Moon with *Ranger IX*. My unsolicitated proposal is to eject an explosive projectile during the terminal phase and have it impact within the field of view. If it were fuzed with a deceleration striker (old-fashioned bomb fuze) it would detonate at a depth dependent upon the strength of the lunar surface material. The resulting photos and craters could be extrapolated to provide an approximation of bearing strength.

Development of such an experiment could not meet the present schedule for *Ranger IX*, but with the unfortunate failure of *Centaur-Surveyor* the present *Ranger* schedule should be less critical.

Vance Haynes
Geochronology Staff
The University of Arizona
Tucson

To the Editor:

I enjoyed your March 1 editorial very much. It appears that your unsolicited proposal will run headlong into Kelleher's First Law—that the inertia of eminent scientists is directly proportional to their eminence.

You have undoubtedly found that the inertia has no relationship to any equations involving logic or dollars. In addition, the law is more pronounced in societies which have reached their peak as compared with those struggling upward. Witness Goddard's problem in the acceptance of rockets as opposed to the growth of rocketry in Germany and Russia.

K. S. Kelleher
President
Keltec Industries, Inc.
Alexandria, Va.

RCA Film Processor

To the Editor:

The article on the RCA High-Speed Film Processor and ASW Program (M/R, March 1, p. 34) was a gem. It gives the only clear and straightforward explanation of this highly complicated subject we have seen—and does this in spite of the security classification of certain important areas of ASW/USW work.

We think Mike Getler is to be congratulated for tracking this story down and developing it through a series of rather difficult interviews.

G. W. Van Citters
Public & Customer Relations
Missile & Surface Radar Div.
Radio Corporation of America
Moorestown, N.J.

Marines' Hawks

To the Editor:

In M/R, Feb. 15, p. 12, you mentioned that "the Army's *Hawk*" was in Viet Nam. In the Feb. 19 issue of *TIME* magazine, they state that a Marine battalion of *Hawk* missiles is at Danang airfield. As a Marine and as a reader of M/R for the past year, I feel that your article needs clarification. Many people do not realize that the Marine Corps has many sophisticated weapons and electronics systems. The Marines, after training with the *Hawk* for four years, would feel slighted if proper credit were not given for their hard work.

Dunken H. McNitzky
Sgt., USMC
"A" Btry, 3rd LAAM Bn
Cherry Point, N.C.

Reader McNitzky is eminently correct, and M/R should not have labeled the Hawk as a strictly Army weapon. Of course, the Army has been, and continues to be the principal buyer of Hawk.—Ed.

Frequent Reference

To the Editor:

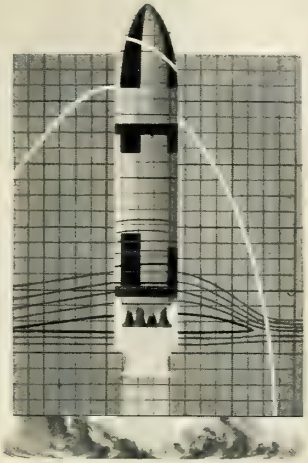
I nominate for a gold medal in repetitive name-dropping the article "'Moon Glow' Will Aid in Mapping" (M/R, March 1, p. 25).

In roughly 1½ pages of text we find: "Amdursky notes"; "under M. E. Amdursky"; "says Amdursky" (three times); "says M. E. Amdursky"; "Amdursky says" (three times); "Amdursky also"; "Amdursky feels."

When I finished I felt I didn't really care how Amdursky feels.

Peter M. Millman
Head, Upper Atmosphere Research
Radio and Electrical
Engineering Division
Engineering Division
National Research Council
Ottawa, Canada

P.S. In all seriousness, however, I couldn't get along without your excellent weekly and find that I refer to it more than to any other space journal.



LOOK AT
LOCKHEED...IN
AEROMECHANICS

At Lockheed Missiles & Space Company, Aeromechanics encompasses many diversified technologies. Typical areas of research and development include:

THERMODYNAMICS—Ascent and entry aerodynamic heating, fluid mechanics, thermodynamics of propulsion devices and cryogenic propellants, and thermal characteristics of materials.

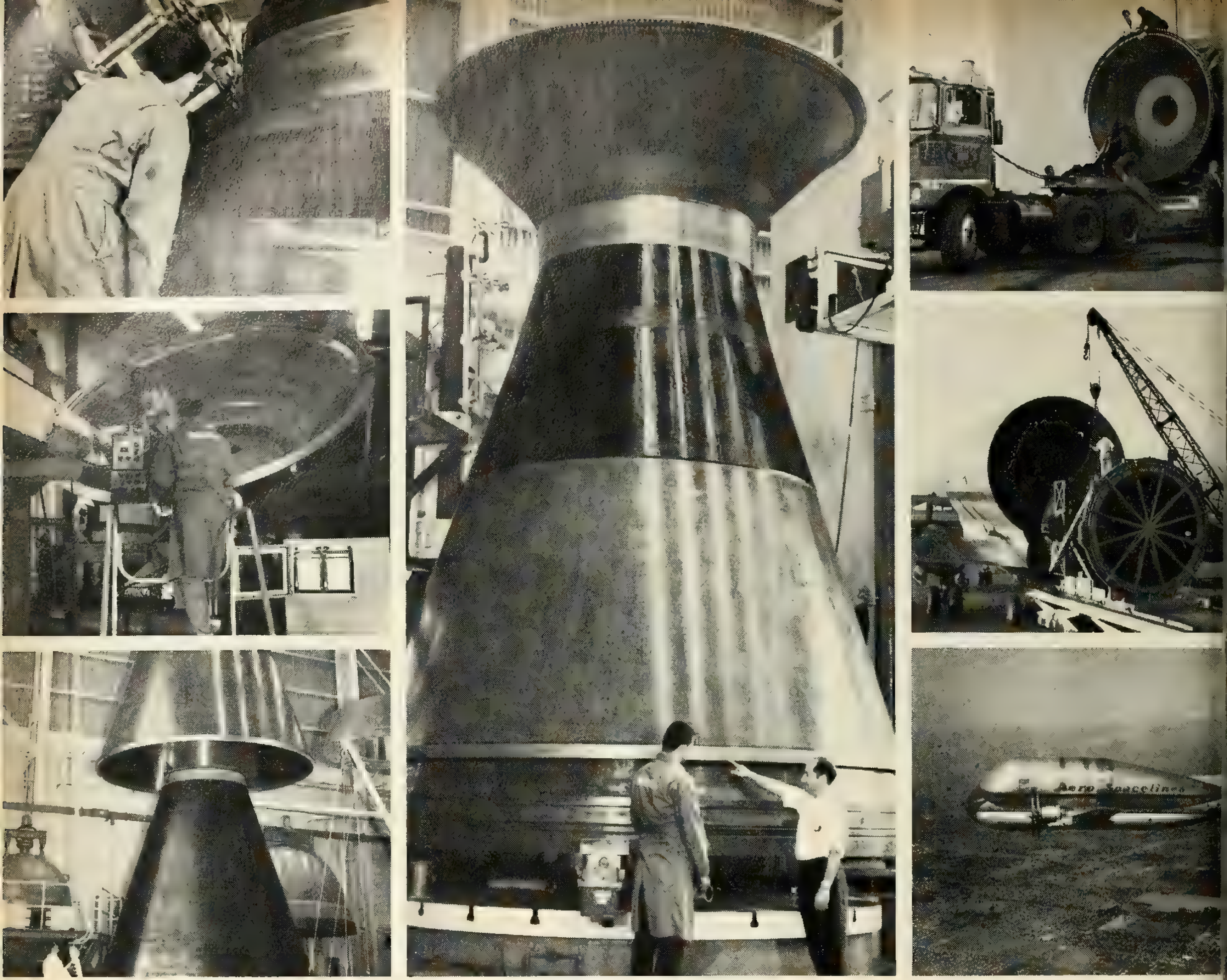
AERODYNAMICS—Rarefied and continuum aerodynamics, gas dynamics, hydrodynamics and external fluid dynamics, engineering mechanics.

STRUCTURAL DYNAMICS—Basic loads, environments, structural criteria, aero-elasticity, shock, vibration, acoustics, and structural feedback functions for analysis of controls stability.

Scientists and engineers in these disciplines at Lockheed have already made significant contributions to such major projects as the POLARIS Fleet Ballistic Missile and the AGENA booster/satellite. Candidates with advanced degrees: Accept this opportunity to make *your* contribution to more advanced missiles, space, entry and hydrodynamic vehicle systems. Address: Lockheed Missiles & Space Company, Dept. 530, P. O. Box F504, Sunnyvale, California.

LOCKHEED
MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

An equal opportunity employer



THE SHAPING AND SHIPPING OF THE WORLD'S LARGEST NOZZLE

This 10-ton solid booster nozzle, built by Rohr for Thiokol, gave a perfect performance at some 3 million pound thrust during recent test firing at Brunswick, Georgia, as a part of the Air Force's large, solid booster feasibility program.

This nozzle, built for Thiokol Chemical Corporation and the U.S. Air Force's Space Systems Division, is the largest ever built — 168″ diameter at exit cone. The nozzle's tape-wrapped, ablative throat and liner sections consist of carbon, graphite and silica fabric impregnated with phenolic resins. They were wrapped (on a mandrel) under precisely controlled tension, temperature and pressure . . . then hydroclave cured at 350° F under a pressure of 1000 psi. During the critical fabrication process, the orientation of the fabric was controlled with tape angles varying from parallel to 60° from center line of nozzle using tape widths of 6 to 13½″. The 4-ton exit cone section alone contains approximately 21 miles of ablative tape. The giant nozzle's structural housing employs thick plate weldments of 18% nickel maraging steel in the heaviest gauge ever fabricated and welded in the aerospace industry.

This Rohr-built rocket nozzle is typical of the advanced technology and fabrication capability available to the industry today at Rohr's new "Hall of Giants" manufacturing facility. For complete information relative to your requirements, please contact Marketing Manager, Dept. 46, Rohr Corporation, Space Products Division, 8200 Arlington Avenue, Riverside, California.

SPACE
PRODUCTS
DIVISION

ROHR
CORPORATION

Circle No. 1 on Subscriber Service Card

The Countdown

WASHINGTON

Army Sees No Long Life for Chaparral

Army indicates no intention of developing *Chaparral* as anything but an interim weapon with an operational life of approximately five years—pending development of *SAM-D* or a much simplified but probably less capable version of *Mauler*. *Chaparral* is the vehicle-mounted adaptation of the air-to-air *Sidewinder*, employing *Sidewinder 1C* with infrared guidance in a launcher equipped to handle four missiles.

Gemini Launch Schedule Is Accelerated

Launch schedules in the *Gemini* program have been accelerated so that the end date in 1967 may still be met in spite of delays in the first few launches. After a design review of *GT-3* last week, manned spaceflight chief Dr. George E. Mueller termed the McDonnell capsule "the best-qualified space vehicle we have seen."

MOL Awards Arouse Speculation

Increase of the number of preliminary design study awards from three to four in the *Manned Orbiting Laboratory* program has led to speculation that Dept. of Defense may be considering award of eventual development contracts to two primes instead of one. Only comment by Air Force and DOD officials, however, was that four firms were chosen nstead of three because proposals by Boeing, Douglas, Lockheed and General Electric all looked so encouraging.

Navy Looks at ASMS

First public mention of a new Navy development related to the *Advanced Surface Missile System (ASMS)* came recently when Robert W. Morse, assistant secretary of the Navy for research and development, told the House Armed Services Committee of requirements for a "point defense missile system" for the fleet. Goal of the effort is to provide a rapid-reaction, lightweight surface-to-air missile system for small vessels and auxiliary ships that are not equipped o carry heavier systems. Pre-project definition studies include possible adaptation of air-to-air missile systems for shipboard use.

Contracts To Be Awarded for X-15 Ramjet

Two contractors are expected to be named in two to hree weeks for design of an experimental ramjet engine o be flown in the *X-15* rocket plane. Test flights under a $5-million program are to begin in late 1967 or 1968.

Up-Rated Atlas Gets Partial Approval

Dept. of Defense and NASA have approved the first phase of a General Dynamics proposal for a 30%-uprated *Atlas SLV X3* booster (see p. 15). This portion covers only reliability improvement by introduction of new components. A go-ahead agreement by the two agencies on the actual ip-rating is expected this month.

Zond II Closing on Mars

NASA officials report that the Soviet Union's *Zond II* pacecraft, which will reach Mars after *Mariner IV*, is expected to pass within 900 miles of the red planet. They also believe because of its heavy weight that it may be carrying a capsule for injection into the atmosphere or down to the surface. An early Russian attempt to explore Venus also is expected. Only a month ago, NASA Administrator James Webb was anticipating that *Mariner IV* would pass closer to Mars than *Zond II*.

Apollo Checks Out in Drop Tests

Drop tests at North American Aviation's Downey, Calif., plant last week demonstrated that the beefed-up substructure of the *Apollo* spacecraft (M/R, March 8, p. 13) now will withstand maximum *Apollo* water-landing conditions. Officials plan a series of 18 more drop tests into water to gather more data.

INDUSTRY

Goodrich Takes Over Suit Development

B. F. Goodrich Corp. has been selected by Hamilton Standard to replace International Latex Corp. as the subcontractor for the garment portion of the *Apollo* spacesuit. Change follows troubles with certain portions of the garment, including shoulder joints, and its ability to provide radiation and meteoroid protection.

North American Gets ATGAR Contract

North American Aviation's Columbus Division has received its third contract from Air Force Systems Command for procurement of a test batch of *ATGAR* air-to-ground anti-tank missiles. *ATGAR*, originally an in-house project of NAA, received its first AF funding last June. Latest contract is for $1,304,400 and covers missiles for continued testing at Eglin AFB, Fla.

Bill To Aid Needy or Greedy?

A freshman member of the House Science and Astronautics Committee says he will offer legislation to force NASA to award one-half of all its Phase I research and development contracts on a geographic basis—to states which are low in NASA funds. Rep. Weston Vivian (D-Mich.), who sits on the subcommittee on Space Sciences and Applications, also is a founder of the Conductron electronics firm.

NASA Pleased with Boeing Contract

NASA officials are very pleased with the way the *Lunar Orbiter* incentive contract with the Boeing Co. is working out. Associate Administrator Dr. Homer E. Newell says that as a result of the contract, Boeing is applying additional pressure on subcontractor prices with a considerable savings to the government.

INTERNATIONAL

Cost Reduction—French Style

The intermediate range ballistic missile *(SSBS)* which the French are developing to replace the Mirage IV bombers in 1968 will share 75% of its components with the French fleet ballistic missile *(MSBS)* now under development for French nuclear subs.

New French Solid Is Forecast

Industry observers in Paris anticipate a French move to develop a solid-propellant equivalent for the *Emeraude* rocket. *Emeraude* has run into difficulty in testing and even its supporters admit it has not been too successful.

The Missile/Space Week

Early Bird Due at Cape

The first *Early Bird* communications satellite is slated for delivery at Cape Kennedy this week, according to Hughes Aircraft Co., which designed and built the satellite for the Communications Satellite Corp.

On March 8, Hughes announced that launch of the synchronous-orbit *Early Bird* would take place in early April. A day later, after Comsat Corp. raised objections, the statement was changed to read that it "could" take place in early April, adding that the exact date would be determined by Comsat. The launch, originally scheduled for late this month, was postponed when checkout tests uncovered defective transistors. Further checkout of the satellite, with transistors replaced, was scheduled to continue until late last week.

Once the satellite is in orbit, Comsat will conduct approximately six weeks of experimental testing of all its communications capabilities. These include 240 two-way telephone channels linking Europe and the U.S. and facilities for television, teletype and photo facsimile transmission. If successfully orbited in early April, the satellite is expected to be put to public use sometime in June.

Comsat Corp. has contracted with NASA to launch the 80-lb. *Early Bird* aboard a *Thrust-Augmented Delta.* Space maneuvers—which will put the satellite into a near-stationary orbit 22,300 mi. over the Atlantic Ocean at approximately 27.5 degrees west longitude—will take about 39 hours.

Hughes has predicted a life of 5 to 20 years for the satellite's electronics system and solar cell power. A much shorter life span—2 to 4 years—is expected for the control system due to expected decomposition of the hydrogen peroxide fuel. Although *Early Bird* may drift slowly westward once control is lost, Hughes pointed out that this would not mean an end to its communications capabilities.

NAA, Northrop Get Condor PDP

Program definition studies of the *Condor* (AGM-53) Navy air-to-surface missile have gone to North American Aviation's Columbus Div. and Northrop's Norair Div.

Negotiations for contracts with each firm are in progress, with only the precise dollar amounts still to be determined by representatives of Navy's Bureau of Weapons.

Condor, a missile reportedly intended for use on both the F-111B and A-6A aircraft, was developed by the Naval Ordnance Test Station at China Lake, Calif. The new weapon reputedly has a range of 40 miles. In addition to the surviving competitors, other firms submitting proposals included: Douglas, Bendix, Grumman, Hughes Aircraft, Martin, McDonnell and Raytheon.

MSFC Awards $58.3 Million

The Marshall Space Flight Center has selected nine firms to provide various engineering, fabrication and institutional support services for one year at a total cost of $58.3 million.

Six laboratories and three other Marshall offices will be involved. Approximately 4,700 personnel will be required to provide the services.

The cost-plus-incentive-award-fee contracts are divided into six laboratory engineering support contracts and one office support contract, which include provisions for four additional one-year renewals. The two contracts for institutional support services have provisions for two consecutive one-year extensions.

The work is primarily in support of the nation's *Saturn/Apollo* launch vehicle program.

Sperry Rand Corp.'s Space Support Div., Huntsville, Ala., will support the Astrionics Laboratory. It will provide approximately 880 engineers, technicians and other support personnel under a contract totaling approximately $12,690,000.

Brown Engineering Corp., Huntsville, under a $12,350,000 contract will provide support to the Propulsion and Vehicle Engineering Laboratory and will employ approximately 920 personnel.

Vitro Corp.'s Vitro Services Div., Ft. Walton Beach, Fla., under a $4,101,000 contract, will employ 550 personnel to support the Test Laboratory's work in large booster and component testing. The support work includes data acquisition and instrumentation for all test operations; and reduction of test data acquired from component systems, subsystems, dynamic, engine and booster testing operations.

Hayes International Corp., Birmingham, Ala., will support the Manufacturing Engineering Laboratory with some 355 people required under the $6,835,000 contract to support the laboratory in the manufacture assembly and checkout of experimental and prototype boosters and space vehicles.

Northrop Corp.'s Northrop Space Laboratories, Huntsville, will support the Aero-Astrodynamics Laboratory Some 200 engineers, scientists, and other support personnel are to be employed under the $3,905,000 contract

Spaco, Huntsville, under a $7,002,000 contract will employ some 540 personnel to support the Quality and Reliability Assurance Laboratory.

Rust Engineering Co., Birmingham, Ala., under an $830,000 contract, will support the Facilities and Design Office. Some 70 architects, engineers, draftsmen, planners and editor-writers will be employed.

RCA Service Co., Camden, N.J. will support the Management Services Office. The $5,030,000 contract will involve 840 people.

Management Services Inc., Oak Ridge, Tenn., under a $3,903,000 contract, will provide support services to the Technical Services Office.

Hercules To Manage Poseidon

The Hercules-Thiokol team now negotiating with Lockheed as the prime for a program definition phase study of Navy's *Poseidon* missile wil feature Hercules as project manager

Hercules would also produce the filament-wound motor chambers and Thiokol would cast the propellant Assembly and testing of the motors would be accomplished by Hercules at its Bacchus, Utah, facilities.

LTV Appears Pact Winner

Ling-Temco-Vought, Inc., is the apparent low bidder with a figure o $21,925,774 for modification of two Victory (VC-2) type ships for use a range vessels in the *Apollo* program (M/R, March 8, p. 34).

The Navy expects to make actua award of the contract later thi month. The eight other bidders fo the modification work include: Bendix, Fishback & Moore, ITT Federa Labs, Philco, Westinghouse, RCA Hughes and General Dynamics.

Arms Agency Dealt Blow

The Senate has passed an ac amended to extend the Arms Contro and Disarmament Agency for tw more years with an appropriation o $20 million.

The amendment to the Arms Con

"Follow the man from Schiller Park.
He's showing a new Portable Dynograph® Recorder at IEEE.
It's priced under $1,300.
You ought to see it!"

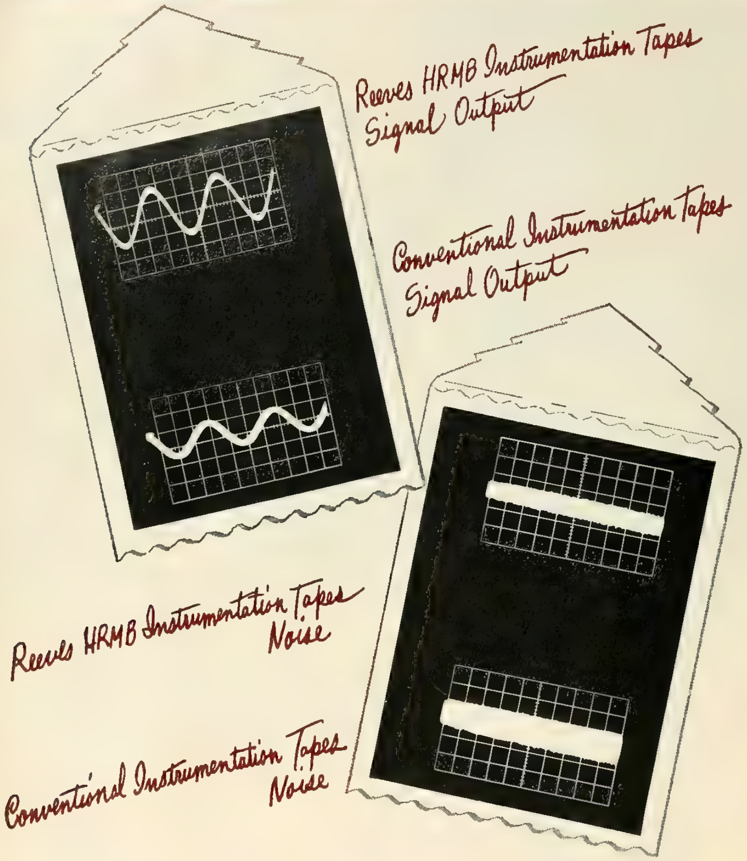
Visit Booth 3407. Learn how you can save $500 or more on your next 2-channel direct-writing recorder. It's available with ink curvilinear, ink rectilinear or heat rectilinear recording media. It weighs less than 40 pounds, provides millivolt sensitivity, extreme ruggedness and maximum operator convenience. If you can't see it at IEEE contact your local Offner Division Sales Engineering Representative or write for Data File 718.

Beckman® INSTRUMENTS, INC.
OFFNER DIVISION
SCHILLER PARK, ILLINOIS • 60176

INTERNATIONAL SUBSIDIARIES: GENEVA, SWITZERLAND; MUNICH, GERMANY;
GLENROTHES, SCOTLAND; PARIS, FRANCE; TOKYO, JAPAN; CAPETOWN, SOUTH AFRICA

Circle No. 3 on Subscriber Service Card

SEE WHY THE NEW
REEVES INSTRUMENTATION TAPES ARE THE
ONLY TAPES YOU CAN AFFORD TO USE?


Reeves HRMB Instrumentation Tapes
Signal Output
Conventional Instrumentation Tapes
Signal Output
Reeves HRMB Instrumentation Tapes
Noise
Conventional Instrumentation Tapes
Noise

This dramatic advance in performance is the result of Type HRMB's special oxide and binder system combined with MICRO-PLATE* — Reeves Soundcraft's exclusive new process which produces the smoothest surface in a tape today.

In addition to its better signal output and noise characteristics, Type HRMB offers these improvements over conventional instrumentation tapes:

• Lower distortion • Freedom from shedding (oxide and binder are locked together) • Lower head temperatures and less abrasiveness — assuring longer head and tape life • Higher electrostatic conductivity for uniform static drain.

Available in "A" oxide for normal bandwidth applications—"B" oxide for extended bandwidth applications. Write for new Reeves Soundcraft Instrumentation Tape brochure.

Polaroid photos are actual tests of tapes run on Sangamo Model No. 4742 recorder reproduce system.

*Reeves Soundcraft T.M.

REEVES SOUNDCRAFT
DIVISION OF REEVES INDUSTRIES INC.
GREAT PASTURE ROAD, DANBURY, CONN.

New York • Chicago • Los Angeles • Export: C.B.S. International, 46 E. 52 St., N.Y.C. • Canadian Reps: Toronto

Circle No. 10 on Subscriber Service Card

trol and Disarmament Act by the Senate Foreign Relations Committee cut by half President Johnson's proposal for a four-year extension of the agency and a budget of $55 million.

The cut reflected the committee's doubts about the agency's study contract program, which constitutes 70% of the proposed budget. Chairman J William Fulbright (D-Ark.) said the committee wants to assure itself that the agency "did not engage in peripheral or unrealistic projects."

As an example, he questioned the necessity and value of a contract for a historical analysis of arms control and disarmament agreements from 1919 to 1939. Limiting the authorization to two years will allow the agency to reappraise its contract research program, Fulbright said.

The House of Representatives had earlier approved an authorization of $40 million for three years.

Martell Cites ASW Needs

In reviewing his activities as Navy's new director of antisubmarine warfare programs for the first time before the House Committee on Armed Services, Vice Adm. Charles B. Martell outlined the urgent need for "an increase in the level of technical management" of ASW.

To beef up Navy in-house capacity in this respect, additional engineering and consultant services have been obtained outside the service through contract, Martell said last week. Extending tours of duty for engineering officers from four to six years in an assignment has been another approach to insuring greater technical expertise in the ASW program.

Phoenix Flight Tests Set

First flight for the Navy's *Phoenix* guided missile is scheduled for March, 1966, Robert W. Morse, the Navy's civilian R&D chief has told the House Armed Services Committee.

First test launch is planned with an A-3A Skywarrior as the airborne platform. An increased FY 196 budget request totaling $71.2 million has been coupled with reprogramming of FY 1965 funds to overcome unforeseen early development difficulties and the program is now proceeding smoothly, Morse reported.

Stretchouts in delivery dates for early prototypes of the F-111B airplane, for which the *Phoenix* is being designed, were necessary to match the *Phoenix* lag, Navy spokesme said. But this adjustment is not expected to delay operational deployment of the F-111B, complete with its missile system. The first experimental *Phoenix* missile and its control system have already been assembled and Hughes began testing from a ground facility this month.

Shots of the Week

The Navy on March 5 fired a *Polaris A-2* from a Cape Kennedy land pad, the first land firing of that missile since Dec., 1962. Announced purpose of the shot was "to test re-entry systems accuracy."

- The Air Force launched a *Titin I* ICBM from Vandenberg AFB, Calif., March 5 as one shot in a series of tests to determine compatibility of the missile with various payloads.
- The Soviet Union launched *Cosmos 59* on March 7.
- France announced March 8 that its *Emarald* space satellite booster stage has been successfully launched after two previous failures. Shot was made in the Sahara.
- The Air Force on March 9 launched a *Thor-Agena* vehicle from Vandenberg AFB, Calif., carrying a satellite of undisclosed type.

March 16 Named Goddard Day

Vice President Humphrey will address the eighth annual Goddard Memorial Dinner, honoring the late Dr. Robert H. Goddard. The dinner, sponsored by the National Space Club, will be March 19 in Washington, D.C.

Congress last week approved an amendment setting aside March 16 of each year as a special day in honor of Goddard. On that date in 1926, Goddard fired the first successful liquid-fueled sounding rocket in Worcester, Mass.

RL-10 Contract Extended

NASA has awarded Pratt & Whitney a two-year extension on its contract for development of the RL-10 engine which is expected to be worth $19 million.

The new cost-plus-incentive-fee contract will carry the work through Sept. 30, 1967.

The space agency also announced that the value of the Raytheon Co. contract for *Apollo* digital display systems will be $3.7 million. It will cover nine display systems and their consoles.

Trans World Airlines was also given a second one-year extension of its support contract for the Merritt Island Launch Area at Cape Kennedy. It will be worth $15.6 million.

What weighs
a million pounds and flies?

Right now, they're calling it CX-HLS. (Aside. Anybody getting tired of the initials gambit? It could be Charles Xavier, Heart and Lung Specialist. It's really Cargo Experimental-Heavy Logistics System.) This will be an elephantine aircraft which **a** might weigh as much as a million pounds, **b** might carry a payload of 250,000 pounds, **c** must carry that payload over practical ranges and **d** (hold onto your hats) must be able to use austere, support airfields close to the point of need. Want to set a million pounds of aircraft down on a short runway with CBR of, say, 8? (There go those initials again. CBR stands for California Bearing Ratio and is the standard for describing ground-surface firmness. One-hundred is the hardest. Eight is fair muddy.) At Hydro-Aire, it is a fairly simple problem, at least from our own end of the picture which is anti-skid braking systems. We are assuming, of course, that one of the three fine companies working on this project will come up with a special high flotation landing gear. Maybe twenty or thirty tires instead of the usual ten, with tire pressure at 25 pounds instead of 80 or 90. To this is added, of course, Hydro-Aire's Hytrol Mark II anti-skid braking system. She'll sit down with ease and safety, no fade, no blow-outs, no wheel lock-ups, no skid. All one million pounds. Hydro-Aire has been doing it for years. Almost every commercial and military aircraft in the 15-300,000 pound range flying today is equipped with Hytrol (when was the last time you heard of a wheel lock-up?). This is undoubtedly the most reliable, tested, safest system utilizing solid-state, servo techniques. Technically, a frequency-modulated transducer is used to detect wheel speed. Control circuitry is then employed to sense the rate of change of wheel speed which, in turn, drives a two-stage servo valve to modulate brake pressure. Locked-wheel control circuitry and pressure bias modulation complete the basic system. When the idea for the CX-HLS first came up, somebody must have said, "Let's put a stop to this thing." Hydro-Aire can.

HYDRO-AIRE
3000 Winona Avenue, Burbank, California
DIVISION OF CRANE

Circle No. 2 on Subscriber Service Card

ASW game changes . . .

Flying Submersible Found Practical

Convair study of 'Sub-plane' reported at AIAA/Navy symposium; Rand doing similar work for Air Force; deep-sea technology advances

by Rex Pay

SAN DIEGO, CALIF.—A flying submersible is practical and will greatly enlarge the problems of anti-submarine warfare.

Practicability of a two-man flying submersible has been shown in a study carried out by General Dynamics/Convair for the Airframe Design Division of the Bureau of Naval Weapons. Emphasis was placed on a moderate aircraft range of 300-500 nautical miles, together with an underwater range of 50 nautical miles at 5 knots and 75-ft. depth.

GD/C said the aircraft, called "Subplane" by the Navy, would weigh 16,000 lbs. and have a 500-1,500-lb. payload. It would have three jet engines—two mounted on pylons above the wing, for extra thrust on take-off, and one atop the hull behind the wing for cruising flight. It would fly at 150-225 knots and have a retractable hydro-ski to assist in take-off.

Underwater propulsion would be similar to that of the Aluminaut (M/R, Sept. 21, 1964, pp. 75 & 76), built by Electric Boat Div. of General Dynamics for Reynolds Metals Co.

The concept is the result of a six-month, $36,000 study for BuWeps in which Convair was aided by Electric Boat.

In contrast, the Rand Corporation is studying strategic submersible aircraft for the Air Force. Clearly, demonstration of the practicality of bi-medium vehicles opens up a whole spectrum of new studies, in which nomenclature will be determined by the sponsoring agency.

Results of these two studies, and others that included a deep-diving ballistic missile submarine and an open-ocean ASW seaplane, were presented at a three-day Marine Systems and ASW Conference held here under the joint sponsorship of the Navy and the American Institute of Aeronautics and Astronautics.

• **All bets off**—Discussing the implications of flying submersibles with MISSILES AND ROCKETS, Vice Adm. John T. Hayward, commander of the Pacific Anti-Submarine Warfare Force, pointed out that one factor now aiding an ASW force is its knowledge of the ports of origin of hostile submarines. The flying submersible would wipe this advantage out.

Hayward said an ASW force can monitor the ports of exit of hostile submarines. If a submarine exits slowly, the ASW force will have estimates of its probable locations and, by continually checking these, can detect when it has left the port. If the submarine moves from its home waters quickly, to make its probable location encompass a much broader area, the noise of its passage can be easily detected.

By these means, he said, knowledge of the number of hostile submarines and their ports enables a constant check on where they are going and what they are doing.

But the flying submersible, being much more flexible in its take-off points, denies most of this advantage to the ASW force. Hence, said Hayward, such a vehicle is of very real interest to the Navy.

• **Growing marine interest**—The joint meeting at which future marine systems were discussed was part of the Navy's program for informing industry, on a classified basis, of the meaning and intent of the official DOD Five Year Force Structure and Financial Program. It also gave industry the opportunity to present its view of how the Navy's requirements could be met.

Well over 1,000 registrants were recorded at the conference, which thus contrasted sharply with the poorly attended AIAA Unmanned Spacecraft Conference held in Los Angeles the week before. The aerospace industry's increasing interest in marine systems was very evident.

The potential of the ocean exploration program to match the scope of space exploration was suggested by Rear Adm. D. W. Knoll, commander of the U.S. Oceanographic Office. Knoll pointed out that because knowledge of the oceans affects such things as weather prediction, transport, food supplies, mineral supplies, and defense, ocean technology penetrates every branch of government.

• **Pluses and minuses**—The mission of the flying submersible was described by C. R. Tuttle of GD/Convair as combining 1) the relative high speed of approach to a target area of an aircraft with 2) the stealth and obscurity near the target of a small submarine. In some ways it is an extension of another study that showed the feasibility of a submersible hydrofoil vehicle.

Main problems with the submersible aircraft were found to be provision of controlled buoyancy, obtaining balance and control in both air and water, finding suitable materials, and ensuring habitability and survival.

For controlled sinking, a high-density aircraft must be used and all excess volume must be flooded. This includes fuel tankage emptied during the outward trip, and wing, tail and body structures. Flight engines must be mounted high for water take-off. They must also be capable of being flooded or else must occupy a small space when sealed against salt water.

Underwater operation can rely on power from batteries or from fuel cells or gas generators, when these become available.

One of the main problem areas is that the aircraft's high wing loadings and the need for a high lift coefficient bring problems when the vehicle operates at high speed under water. (Apparently the Convair study looked beyond five knots.) Possibly a variable geometry wing system may be required

• **Deep-down alternative**—Another approach to the problem of a submarine's vulnerability to detection on leaving port is to be seen in the Manned Bottom Mobile System. A deep-diving vehicle capable of long missions, MBMS would use deep sonar-shadow zones to elude monitoring ASW forces and make for fewer returns to port. This would greatly increase the area of its probable location.

Studies of a deep-diving ballistic missile submarine carried out by West inghouse as part of the Advanced Sea Based Deterrent Study have led to a preliminary technical development plan for a recommended MBMS concept. It is designed for deployment in the next 10 to 15 years and would be a self-propelled submarine with minimum crew complement.

- **Progress downward**—Rapid progress in deep ocean technology during the next decade was forecast by J. P. Craven, chief scientist, Special Projects Office, Department of the Navy. He said the transition is under way from a surface-oriented technology to one that is completely submerged.

Selecting specific areas of improvement, Craven said that power and propulsion techniques would progress from silver-zinc batteries, through fuel cells and isotope power sources to the ultimate use of reactors and hydrogen-oxygen fuel cells. Control systems may evolve from rotatable propellors through variable pitch configurations to pure hydrodynamic systems, he said.

Excellent results with programmable pitch propellers in controlling a model submarine were reported by Cdr. F. R. Haselton, Office of Naval Research. Viewed externally, the propellers appear as radial blades mounted on circumferential bands around the bow and stern sections of the submarine. Large hub-to-tip diameter ratio contra-rotating propellers are obtained and propeller blade pitch is collectively or cyclically variable, producing six-degree of freedom control of the vehicle. The system can also augment high-speed stability.

Tests in the David Taylor Model Basin, Carderock, Md., showed the system has a potential for substantially improving the low-speed maneuverability of submarines, said Haselton.

- **Information massive**—Knoll and Hayward both emphasized the importance of information-processing techniques. In oceanography and in ASW there is an explosive growth in the amount of information being obtained. Fleet Ballistic Missile submarines are being used to collect oceanographic information; on-board data reduction systems correct for vessel motions and present results as strip chart recordings and power spectral density plots. Further applications of on-board data-processing systems of this type are likely.

In discussing monitoring and detection of submarines, Hayward spoke mostly of use of information theory and statistical probabilities. He said there is a pressing need to handle large amounts of information from oceanographic sensors in a way that eliminates false clues of the presence of a submarine.

- **Pacific immensity**—Discussing ASW strategy and operational problems, Hayward pointed out that the Pacific is a very different arena to the Atlantic and that the legacy of the Battle of the Atlantic may have some faults. "I can't see that the same ideas apply," he said.

He said that all great-circle routes in the Pacific are under threat, no bases comparable to Iceland or Greenland are available, no comparable array of air bases can provide coverage of the ocean, and no equivalent of the European Navies is present. The size of the Pacific—65 million sq. mi.—puts strategic planning and tactical follow-through in a class of their own.

In such a vast area, one of the headaches of an ASW force is in maintaining contact with a hostile submarine once it is detected. A possible solution is an ASW seaplane of the V/STOL type that can stay on station in the open ocean for long periods of time, taking off and landing in high seas.

Studies of an aircraft of this type are being carried out at the David Taylor Model Basin. With good payload-range characteristics such a craft is capable of maintaining uninterrupted contact with targets. Results of aerodynamic tests on a seaplane model with suitable characteriestics were presented at the conference by a group of engineers from DTMB, together with estimates of potential cost-effectiveness. ■

Army Spells Out Its $253.7-Million Missile Request

FIRST BREAKDOWN of the $253.7-million Army request for missile systems procurement in Fiscal Year 1966 was given in testimony before the House Committee on Armed Services by Maj. Gen. F. J. Chesarek, assistant deputy chief of staff for logistics. Amounts listed for operational tactical weapons systems or systems destined for procurement are shown in the accompanying table.

Of the $52-million request for *Pershing*, $42.8 million is the basic funding request, with an additional $9.2 million for modification of in-service missiles and ground equipment previously received from the manufacturers. The $1.9 million requested for *Honest John* will be for "an economical buy" of practice warheads to meet requirements through FY '70. For *Little John*, $0.5 million for practice warheads and telemetry equipment is listed. Besides the $1.9-million total for *Sergeant*, for engineering and quality assurance costs, the Army is asking for an additional $3.4 million for modification of the missile. (This latter amount is not included in the total given in the table.)

For second-year procurement of *Shillelagh*, $60.9 million is requested. The $2.7 million for *SS-11* will complete the planned buy of this wire-guided anti-tank missile. First procurement of *Chaparral* is planned in FY '66; $20.4 million is requested.

In the case of *Redeye*, first procurement was authorized in FY '64, only to be delayed for further research and development effort. R&D is now complete, and the Army is asking for $58.3 million for initial procurement. The $6 million listed for target missiles includes $5.4 million for the *Redhead/Roadrunner* and *Radio Plane-76* systems and an additional $0.6 million for infrared kits and ground control equipment.

"Other Missile Costs" totaling $49.1 million includes: $26.6 million for modifications of missiles now in service; production base support, $1.7 million; transport to the weapons' first destination, $4.1 million;—plus $16.7 million for spares and repair parts. Of the $26.6 million in modification money, $10.6 million is for modification and improvement of fire control equipment for *Nike-Hercules*. Another $3.4 million is for modifying operational *Hawks*.

FISCAL YEAR 1966 MISSILE AUTHORIZATION REQUESTS FOR ARMY MISSILE SYSTEMS

SURFACE-TO-SURFACE	($ Millions)* FY '66 Program
Pershing	52.0
Honest John	1.9
Little John†	.5
Sergeant†	1.9
Shillelagh	60.9
SS-11	2.7
SURFACE-TO-AIR	
Chaparral	20.4
Redeye	58.3
OTHER SYSTEMS	
Target Missiles	6.0
OTHER COSTS	
Modification of In-Service Missiles	26.6
Production Base Support	1.7
First Destination Transportation	4.1
Spares and Repair Parts	16.7
TOTAL	**253.7**

*Includes cost of associated ground equipment.

†Bought out in FY '64.

In Webb letter to House . . .

NASA Asks to Reshuffle '65 Funds

Overruns necessitate request for transferrals; biggest item is $18.5-million hike for lunar and planetary programs

OVERRUNS in several NASA programs have led to a request for further reprogramming of the agency's Fiscal Year 1965 funds.

The request is contained in a letter from NASA Administrator James E. Webb to Speaker of the House John W. McCormack, and referred to the House Science and Astronautics Committee. Under the law, if neither the House nor the Senate space committee objects within one month after the letter of intention is filed, the action will be considered approved. The request was made March 1.

Largest overages would occur in the lunar and planetary programs, climbing to $206.4 million as contrasted with the authorized amount of $187.9 million. In this category, supporting research and technology funds would be increased from $18.1 million to $22.3 million, for increased work on sterilization and advanced technical work related to *Voyager*. Manned Space Sciences would be upped from $5.8 million to $6.36 million, for added effort on scientific experiments connected with *Apollo*.

Problems encountered in the *Ranger* program last year will require a jump from $6.8 million to $15.5 million during FY '65. The *Ranger VI* failure necessitated corrective action, and slippage of one year in the flight schedule for the final two launches. Added ground testing also contributed to the need for extra funding.

Surveyor funding would be raised from $74 million to $76 million. *Mariner* funds, which were authorized at $41.2 million, would be reassigned to $21 million for *Mariner* and $7.7 million for *Voyager* Phase I studies. The remainder, which was made available because of the cancellation of the Mars '66 mission, would go to offset overages in other lunar and planetary projects.

NASA is proposing an increase in *Pioneer*, from $13 million to $15 million, following a re-evaluation of the program which indicated that improvements in the spacecraft system and addition of new experiments would be necessary.

Lunar Orbiter also would get a large increase—from $28.8 million to $42.4 million. This was attributed to a finding that in implementing the incentive contract it would be necessary to spend a greater percentage of the funds in FY '65, with a corresponding decrease in later years.

● **Biosciences** — Another program area receiving attention is biosciences. Here the request seeks an overall funding increase from $25.5 million to $28.7 million. All of this is applied to the *Biosatellite* program, which goes from $12.7 million to $16 million, $100,000 of this being transferred from elsewhere in the area. This would fund changes in design which became necessary as development progressed and the relationship between the experiment requirements and spacecraft configuration became better defined. Additional changes were required by the decision to shift to the improved two-stage *Thrust-Augmented Delta* for the *Biosatellite* mission.

NASA would also like to increase funding for *Advanced Technological Satellites* (*ATS*), from $20.1 million to $23.39 million. In this category, the agency would like to increase supporting research and technology from $1.1 million to $1.7 million, to study stabilization schemes associated with synchronous-altitude satellites. *ATS* program money would be increased from $19 million to $21.69 million, because of development problems with the passive gravity-gradient stabilization system.

● **Space vehicles**—Space Vehicle Systems also would get a sizeable boost, from $34.89 million to $44.49 million. In this area, supporting research and technology would be decreased from $26.3 million to $24.5 million, small space vehicle flight projects from $3 to $1 million, the *Scout* re-entry heating experiment from $1 to .75 million, and the lifting-body flight program from $1.9 to $1.5 million. However, NASA would add money for *FIRE*—an increase from $1.9 million to $2.8 million for modifications to instrumentation aboard the second scheduled spacecraft. These changes were considered advisable on the basis of information obtained from the first *FIRE* flight.

NASA also requests that it be authorized to reprogram money to the *Saturn* launch meteoroid experiments. The agency said increases from $2.6 million to $13.69 million would be necessary for procurement of the third spacecraft for *SA-10*, for meteoroid detector problems, for the 90-day launch delay, and an unforeseen need for additional design testing and spare parts.

Overages in the large solid-propellant motor program and close-out of the M-1 engine program account for the request to raise the chemical propulsion category from the $62.8 million authorized to $78.59 million. (see p. 17.)

In spite of these additions, total R&D funding proposed for FY '65 comes to $4.308 billion. The FY '65 NASA bill authorizes $4.341 billion, so NASA is well within its limit.

● **Underruns**—Funds in a number of other program categories apparently will not be expended during this year, although this money may be spent for its authorized purpose at any time during that year or in the next two years.

Apollo, for instance, is now programmed at $2.628 billion, although $2.676 billion has been authorized. Geophysics and astronomy are listed at $136.8 million, contrasted with $141.3 million authorized. Launch vehicle development is set at $96.5 million, under the authorization ceiling of $114 million. Meteorological satellites are allotted $31.2 million, while $31.3 million was allowed. Comsats will reach $8 million, while $11.4 million was authorized. Others falling under the authorized amount were: electrical systems, $25.4 million from $27 million; human factors systems, $13.32 million ($15.5 million); nuclear electric systems, $44.6 million ($47.1 million); nuclear rockets, $56.7 million ($57 million); aeronautics, $35.2 million ($36.7 million); and launch vehicle procurement, $154.67 million ($157.2 million); tracking and data acquisition, $274.7 ($274.8). ■

Newell tells House . . .

Voyager To Avoid Surveyor Errors

Lack of knowledge, management problems blamed for difficulties in older program; witnesses break down $43-million definition funds

by Heather M. David

NASA HAS MADE IT CLEAR that it is going into the *Voyager* program with the lessons learned in *Surveyor* well in mind.

Associate Administrator Homer E. Newell told the House Space Sciences and Applications subcommittee chaired by Rep. Joseph E. Karth (D-Minn.) that NASA will go into an extensive Phase I study of *Voyager* to avoid the problems which have set *Surveyor* back a total of three years and pushed its cost $264 million over the original estimate.

In answer to committee questions, Newell and Edgar Cortright, deputy associate administrator, said the *Surveyor* program estimate has now increased $140 million over the one presented to the committee last year. In the original *Surveyor* presentation, the total program was estimated at $496 million. Last year, this was raised to $620 million. This year the figures are $531 million already spent, plus $229 million remaining to cover purchase of 17 spacecraft and their vehicles.

Newell said NASA is approaching *Voyager* in a different way, to make sure that all the problems are understood and worked out as well as possible before proceeding to Phase II work.

The $43 million being asked for *Voyager* program definition will be broken down into $3.3 million for project management; $6 million, spacecraft systems; $4.6 million, capsule system; $1.3 million, general support; $16 million, contractor's spacecraft design studies; $3.6 million, propulsion studies; $5.2 million, capsule study; $2 million, experiments; $1 million, ground operations; and $2 million, conceptual studies. Some money will be available from reprogramed FY '65 funds, if Congress approves the move (see p. 14).

- **Surveyor troubles**—Lack of good groundwork has caused a number of *Surveyor's* problems, Newell explained. He told the committee that "when we undertook this program I believe that none of us really had a good feeling for how difficult the project was."

Although the witnesses indicated that the program is now coming out of the woods, a recent review gave rise to a list of 170 improvements which are being evaluated for *Surveyor* spacecraft. Karth pointed out that whereas a year ago four flights had been planned for 1965, all but one now are due to take place in 1966, which amounts to a slippage of one year. The first operational flight is now scheduled for 1967, Newell said.

The recent mishap at the Cape Kennedy launch pad (see p. 18) will not cause delays in the program, Newell said. Damage to the pad is far less than first estimated, and repairs probably will cost between $1 and $2 million.

One of the recent *Surveyor* setbacks occurred in drop tests. NASA witnesses said that the contractor, Hughes Aircraft Co., agrees that the tests "were not properly prepared for or conducted properly." They added that NASA management must also share in the blame, since it did not penetrate deeply enough into the problem. The drop tests were undertaken with non-flight hardware equipment, rather than the flight hardware which reportedly should have been used. This has necessitated building a new T-2 test vehicle.

- **Management**—The subcommittee noted a report that the Jet Propulsion Laboratory has had management problems with the *Surveyor* contract. Karth asked whether it wasn't true that tension between *Surveyor* personnel at JPL and Hughes was getting worse. Cortright conceded that there was tension, probably because the problems *Surveyor* has had have led to tension among all those concerned with it—and because JPL is in the position of "looking over the shoulder" of the contractor.

Newell said changes in management and the organizational setup at JPL and Hughes, leading to a more "projectized" structure, have improved the situation. Asked why *Surveyor* requires about three times as many personnel at JPL as does *OAO* at Goddard Space Flight Center, Cortright said the tight schedule and commitment to the *Apollo* program makes it necessary to see that everything possibly is done to carry out the program successfully.

- **Pioneer**—Newell also told the committee that the *Pioneer* program, which was dropped for a couple of years on the assumption that the *Mariner* interplanetary probes would furnish the same information, probably should have been continued. He said that the extensive variations in the interplanetary weather were not fully appreciated when this decision was made, and that the further cutbacks in the *Mariner* program created a situation in which there would be even less information.

The program is being revived this year, with the first launch set for this September. ■

Atlas Uprating Expected To Cost $15-20 Million

THE GENERAL DYNAMIC Corp. proposal to uprate the *Atlas SLV-3 X,* now being evaluated by NASA and DOD, estimates a cost of $15-20 million.

The modifications, which involve increasing the tankage and slightly uprating engine thrust of the *Atlas* itself, would give the *Atlas-Centaur* vehicle for the *Surveyor* spacecraft a capability of 2,800-2,900 lbs., Dr. Homer Newell said.

About $4.5 million was spent on the now-cancelled *FLOX-Atlas* program, he said. Originally, about $17 million had been approved for the program. However, the fact that the RL-10 engines were uprated to give an additional 300 lbs. of payload capability in the *Atlas-Centaur* made it possible to drop this program. Although the technical problems had by then been largely resolved, the hazards of working with fluorine were still considered great.

After 22-month hiatus . . .

GT-3 To Renew U.S. Manned Program

Three-orbit Gemini flight by Grissom and Young will pave way for longer mission later this year; Soviet spectacular hinted

by Hal Taylor

THE U.S. NEXT WEEK will attempt its first manned space flight in almost two years as the Project *Gemini* two-man series gets under way.

The flight comes as U.S. officials report they are expecting another manned Russian space spectacular in the near future. They said they did not know exactly what type of flight would be attempted, but that it might be the launch of a new spacecraft on a long-duration flight or an orbital rendezvous flight.

The upcoming launch of the 7,000-lb. *Gemini* spacecraft by the *Titan II* booster will be the third flight in the series. The first two flights, on April 8, 1964, and Jan. 19, 1965, were both successful unmanned missions.

The *GT-3* mission—scheduled for no earlier than March 22 or 23—will be a three-orbital flight with Command Pilot Maj. Virgil "Gus" Grissom and Pilot Lt. Cdr. John W. Young at the controls. If successful, the flight will last four hours and 52 minutes. Touchdown is expected to be 70 mi. northeast of Grand Turk Island.

Primary objective of *GT-3* is to test the spacecraft launch vehicle combination as well as its subsystems in preparation for long-duration missions slated later this year and in 1966.

U.S. officials reported, however, that there are indications from behind the Iron Curtain that the Soviet Union is preparing a space spectacular that may surpass, in duration at least, the three- and seven-day U.S. flights scheduled this year.

The officials would not disclose the source of their information except to say that preparations that have been noted in Russia seem to point to another manned flight. At the same time, there was a report in a Russian scientific magazine, *Nedflya*, that a new Soviet spacecraft carrying a woman would be launched this month.

The *GT-3* shot will be the first U.S. manned flight since May 15, 1963, when Maj. L. Gordon Cooper and his *Faith 7 Mercury* spacecraft orbited the Earth 22 times during a 34-hr. 20-min. mission.

- **Minor problems solved**—Early testing and checkout of the *GT-3* spacecraft and launch vehicle moved smoothly with only minor discrepancies, which were quickly fixed.

The final simulated mission run with the prime astronaut team at the controls began about an hour late March 8 because of electrical cable trouble in the ground support equipment. A leak in a Mormon clamp between the second stage and a pre-valve was discovered but quickly stopped. At T minus 6 in the simulated run, there was a four-minute hold when the batteries in the spacecraft adapter did not warm up fast enough. There also was another hold because of a faulty computer reading.

Unless unknown technical problems turn up, it appears that only bad weather in either the launch or recovery areas can postpone the flight. Allowable weather conditions in the launch area are surface winds of no more than 20 mph, and gusts of no more than 28 mph, 5,000-ft. minimum cloud ceiling, minimum visibility of five miles and a maximum wave height of five feet off Cape Kennedy.

In the recovery area, allowable weather conditions include maximum surface winds of 34 mph, minimum cloud-based ceiling of 5,000 ft., minimum visibility of five miles and a maximum wave height of eight feet.

Among the stations that will track the spacecraft are the Mission Control Center, Cape Kennedy; Grand Bahama Island, Grand Turk Is., Antigua Is., Bermuda, Grand Canary Is., Ascension Is.; Kane, Nigeria; Tenanarive, Malagasy; Canarvon, Australia; Canton Is.; Kauai, Hawaii; Point Arguello, Calif.; Quaymas, Mexico; White Sands, N.M.; Corpus Christi, Tex.; and Eglin Air Force Base, Fla. It will also be tracked by the coastal sentry Quebec in the Indian Ocean and the Ranger Tracker and Rose Knot Victory in the Pacific.

The prime recovery method will be the use of a flotation collar around the spacecraft, which will then be hoisted aboard a ship. After recovery, the astronaut team is expected to stay aboard the ship for two days before returning to Cape Kennedy. The capsule will stay aboard the ship until it returns to the Cape.

- **Astronaut tasks**—The astronaut team will be very busy during the *GT-3* mission. A detailed flight plan released by the Manned Spacecraft Center reveals that 145 separate actions will be taken by the command pilot before, during and after the flight. Some 226 duties have also been assigned to the co-pilot.

Many of these duties will be involved in two orbit-changing maneuvers—controlled by the Orbital Altitude Maneuvering System (OAMS)—which are expected to be the most important experiments in the *GT-3* flight.

The first will take place near the end of the first orbit while the spacecraft is being tracked by the Corpus Christi station. It calls for a 66-fps change in velocity by firing the forward firing thrusters for one minute and 40 seconds. This will place the spacecraft in a nearly circular orbit, switching its orbital parameters from an apogee of 130 mi. and a perigee of 87 mi. to an apogee of 93 mi. and a perigee of 87 mi.

The second orbit change will place the spacecraft in a highly elliptical orbit that could be used as a backup re-entry method if the retro-rockets fail to fire. This will be accomplished by bringing the spacecraft's perigee so low that atmospheric drag will slow it down, permitting it to reach safe re-entry velocity.

The maneuver will be made during the third orbit. Grissom will put the spacecraft in re-entry attitude. He then will fire the aft attitude control thrusters for one minute and 46 seconds to produce a 93-fps. retro-velocity change.

This will change the spacecraft's orbit from a closely circular one to a highly elliptical one ranging from an apogee of 85 n.mi. to a perigee of only 45 n.mi.

- **Other tests planned**—Among the other engineering experiments which the two astronauts will attempt are:

—Observation and photography of RCS system plumes to determine degree of occultation of the horizon and degradation of dark adaptation by RCS under night conditions and under daylight conditions.

—The horizon scanner test will evaluate scanner platform torquing efficiency and the performance of the cadging loops and yaw alignment loops to bring the spacecraft back into alignment from a 10° up and down pitch and 10° yaw.

—Food-waste evaluation will begin at hour one plus 40 minutes and last through hour two and 35 minutes.

—A repeat on horizon scan test begins just before sunset at two hours and 10 minutes. The spacecraft will be turned 5° left of the Sun when the Sun is 4° above the horizon. Grissom will set up a rate of 5° per second yaw rate and report observations on the rate of pitch and roll and perturbations set up as scanner system compensates.

—A check of the orbit changing system at two hours and 17 minutes will move the orbit north and south to:

1) Observe plumes, if possible, of the forward thrusters;

2) Evaluate ACME control systems characteristics;

3) Evaluate the spacecraft's stability in the 90° yaw, perpendicular to the orbital track;

4) Evaluate ability to apply small orbit changes by applying 15 sec. of thrust pulse. This will be accomplished by firing the aft thrusters nine and 10 forward translation to one fps, and then the forward thrusters 11 and 12 are fired to translate aft until one fps rate is reached.

—Gauge correlation experiment begins at two hours and 50 minutes. It will attempt to correlate astronauts' radio reports of spacecraft gauge readings with the ground readings from spacecraft telemetry.

—A ground tracking test begins at 2 hours and 57 minutes. Afer fixing the reticle in the window, Grissom will pitch the spacecraft down 16° and try to visually locate the west coast of North America. He will pick the target landmark and try to hold it in reticle, while at the same time co-pilot Young will photograph the landmark.

—Re-entry communications experiment begins at 4 hours and 42 minutes. This is about 90 seconds after the spacecraft passes through the altitude of 308,000 ft. During a 4-min. transmission, water will be injected outside the spacecraft in an attempt to prevent a radio blackout. The exact time and amount of water injection, or flow rate, is classified for military security.

- **Night and day**—On the first orbit, Grissom and Young are expected to enter darkness over the island of Madagascar, now the Malagasy Republic. The pair will move from darkness into daylight over tracking ship RTK, the range tracker at about 140° longitude.

On the second orbit, the men will see their second sunset over the African area of Nyasaland, 30° west of Madagascar, leaving darkness over the Pacific at about 165° latitude.

They will enter darkness again just east of the African coast on the third orbit, emerging almost on the International Dateline between 170° and 180°.

- **Fuel load**—The *GT-3* spacecraft will be loaded with 119.79 lbs. of fuel and 245.89 lbs. of oxidizer, or a total of 365.68 lbs. The flight is expected to consume 115.97 lbs. of fuel and 179.50 lbs. of oxidizer, for a total of 295.47 lbs. NASA expects to use 160.80 lbs. for the orbit-changing maneuvers with 37.65 lbs. to be used in attitude control. One third of the total on board will be a reserve supply of 97.02 lbs., which also may be used for the OAMS employed in orbit-changing.

The rate control system (RCS), which is used during re-entry, has 36.03 lbs. of fuel in each of the two RCS systems for a total of 72.03 lbs. It is estimated that 65.18 lbs. will be used.

The primary cryogenic oxygen supply in the environmental control system totals 15.75 lbs. and 15.30 lbs. is expected to be used. Two secondary gaseous oxygen bottles hold 6.85 lbs. each. ■

Agency Seeks Authority to Transfer Total Of $19.15 Million for 260-in., M-1, SNAP 8 Programs

NASA HAS ASKED Congress for permission to reprogram $14 million in Fiscal Year 1965 funds to continue the 260-in.-dia. solid motor program through Phase I.

It also has asked to reprogram $3 million for the M-1 liquid hydrogen program and $2.15 million for the SNAP 8 project. All three programs are to be canceled after the end of the current fiscal year because no funding was requested for them in the space agency's FY '66 budget.

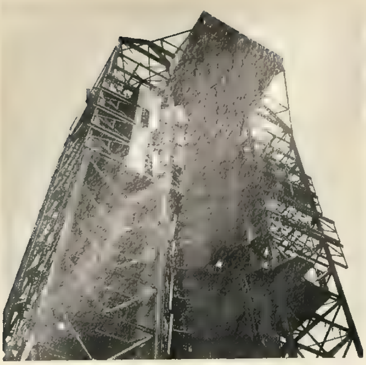
The new funding for the big solid program will permit both contractors, Aerojet-General Corp. and Thiokol Chemical Corp., to fire two half-length motors each. Only about $5.3 million of the reprogrammed funds will be used for that purpose. The rest will be used to pay for cost overruns which stem from technical difficulties encountered in developing the technology for welding of motor cases. Total funds for the program in FY '65, including the original authorization, will now reach $26 million.

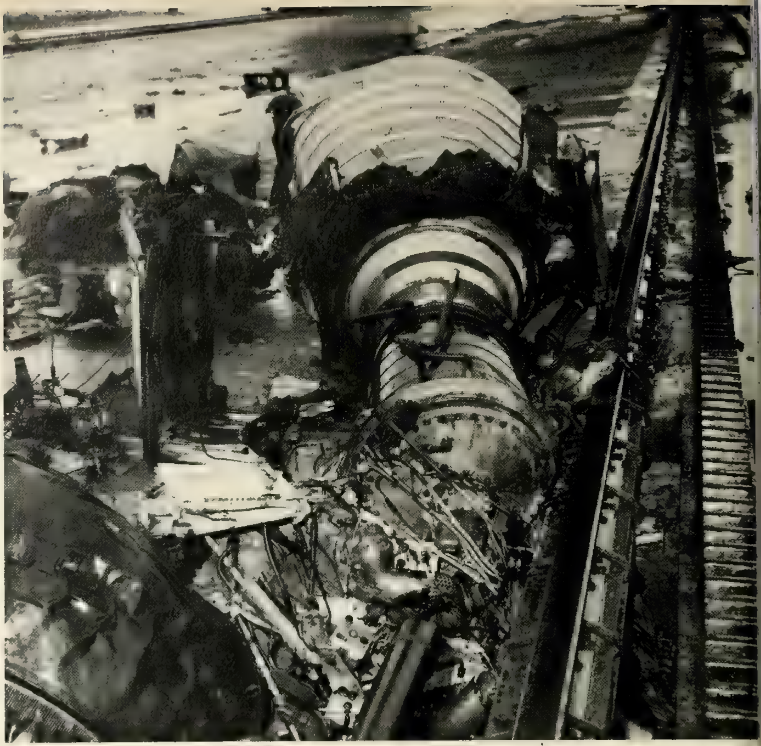
Phase II of the program, which calls for the firing of a full-length motor, will not be approved unless Congress votes the space agency additional FY '66 funds.

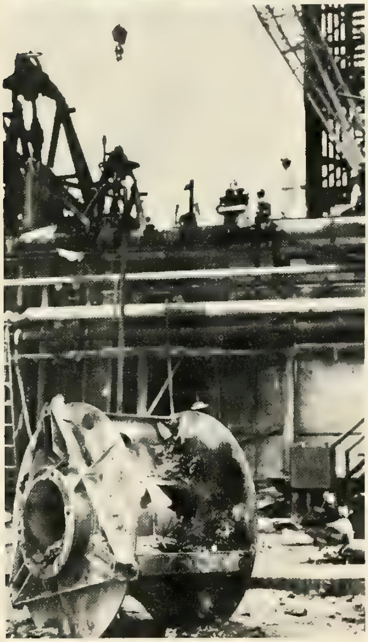
In the SNAP 8 program, the additional $2.15-million request added to $17 million previously authorized will pay for a 10,000-hour-duration run of a Power Conversion Unit. It will also be used to fund 1,000-hour tests of various components. The number of Aerojet-General personnel working on the project is expected to drop from 300 to 250 at the end of FY '65 and to only 70 during the long duration run.

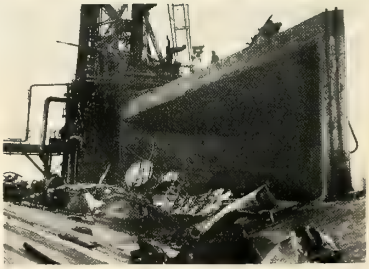
The $3 million for the M-1 program will be transferred from previously authorized construction funds for the engine project. The money will be used for dry tests of the oxygen and hydrogen turbopumps and a combustion test of an uncooled thrust chamber.

Aerojet now employs 837 on the project. This will be reduced to 570 by end of FY '65 and 50 by 1966.









Aftermath of Atlas-Centaur Failure

INVESTIGATORS are trying to determine exactly why a $7,500 "off-the-shelf" prevalve failed and turned the March 2 *Atlas-Centaur 5* launch at Cape Kennedy into a flaming fiasco.

Officials reported last week that the 7-in.-tall, 7-in.-dia. booster engine valve definitely was the culprit in the destruction of the *AC-5* and its payload, a dynamic model of the *Surveyor* spacecraft which was to have been put into orbit. But they were still uncertain as to the cause of the malfunction.

The next *Atlas-Centaur* flight is scheduled for July or August, with another dynamic model of *Surveyor*. Officials say it should be delayed no more than a month as a result of *AC-5's* failure.

- **Stock unit**—The valve, made by B. H. Hadley, Inc., of Pomona, Calif., is a standard item throughout Rocketdyne's MA 5 propulsion system.

In the final 14 seconds of the March 2 countdown, all sequences were normal, officials said. There was proper separation of all launch pad disconnects, and the LOX mixed properly with the RP-1 kerosene. But then the pressure to the fuel pump suddenly decreased to register "no fuel flow." This shut the engines down, although the sustainer kept operating.

The valve initially shut off fuel to only one booster; the other and the sustainer continued for two seconds before the vehicle dropped back onto the pad.

The valve's actuator blew apart from the valve proper. Both were found intact in the wreckage and sent to General Dynamics/Convair for study.

- **Policing up**—The photos above show the scene at Pad 36A shortly after the March 2 *AC-5* launch attempt.

TOP LEFT: Left (west) side of gantry retains paint, but right side is blackened and frayed. Fiberglass panels were all blown out or burned. TOP RIGHT: *Atlas* sustainer engine is examined. Part of booster stage is visible at lower left. BOTTOM LEFT: Base of dynamic model of *Surveyor* after shroud was peeled off. CENTER: Flame bucket containing some of the rubble that once was *Centaur*. Upper stage, two of its four panels still intact, fell into the bucket. RIGHT: Two workmen work on *Atlas* sustainer engine, which landed 200-250 ft. from the gantry.

(Top right photo from NASA; others are M/R photos.)

Technical Countdown

MATERIALS

Giant-Spike Laser Material Perfected

A modified form of neodymium glass is being used by scientists at the Westinghouse Research Laboratories to produce giant-spike operation in lasers—that is, the generation of extremely sharp and powerful individual pulses of laser light. Such operation will prove useful in laser ranging and reconnaissance applications. Normally giant-spike operation is accomplished through a complex optical apparatus outside the laser. The modified neodymium glass moves the operation within the laser rod itself. Ordinarily, since the action of all the neodymium ions throughout the glass rod is random, the energy releases occur at slightly different times. The result is a laser burst consisting of a cluster of small, random spikes of light. The modified glass reduces this random behavior by synchronizing the release of the energy stored by the neodymium ions. The modification is the introduction of a small amount of uranium in the form of uranyl (UO_2^{++}) ions. Part of the research is in cooperation with the Pittsburgh Plate Glass Co.

Fine Beryllium Wire Nears Production Status

A 50,000-ft. coil of 0.005-in.-dia. beryllium wire delivered to the Manufacturing Technology Lab. Research and Technology Div., Air Force Systems Command, represents the first major run through special drawing equipment developed by Beryllium Corp. The program is still in its developmental stages, but additional wire in lengths up to 25,000 ft. have been made. Other gauges have been drawn, including diameters down to 0.001 in. The process at Berylco involves drawing 0.005-in. wire from 0.50-in. rod stock without costly intermediate anneals. Berylco experts also found that encasing the metal in nickel prior to the drawing operation made the use of conventional multiple drawing equipment possible. The wire is drawn under controlled temperatures at 750° F at speeds of 40-60 ft. per min. The wire can be used in composite structures. Both Berylco and Astro Metallurgical Corp. shared in the Air Force-sponsored program.

Russians Researching Space Welding

Remote control welding systems for in-space manned spacecraft repair and assembly of manned space stations are being researched by engineers in the USSR. Welding devices under study include electron beam, nuclear, incandescent plasma, ion beam and laser. The individual units would be incorporated into a completely automatic system that almost instantly determines damage to the structure, indicates pressure drops and initiates an automatic repair cycle. (From *Teknika Molodyezh,* Nov. 11, 1964, translated in EOS, Inc.'s *Soviet Science in the News,* Vol. 3, No. 1.)

Cork-filled Ablative Shielding Marketed

A series of ablative thermal control compounds invented at the Autonetics Div. of North American Aviation are being marketed by Dyna-Therm Corp. under license agreement with NAA's Navan subsidiary. The cork-filled compounds are said to be 50% lighter in the same applications than "conventional silicone-rubber compounds". The family of materials possess excellent adhesion properties and high efficiency and can be used to protect almost any configuration. The major market is expected to be in electronics.

ELECTRONICS

Laser to Study Rocket Exhausts

A laser instrument for sounding the upper atmosphere has been delivered by Stanford Research Institute to the Pacific Missile Range Operations, Point Mugu, Calif. There it will be used to investigate atmosphere characteristics, including contamination of the upper atmosphere by rocket exhausts. The instrument uses two 8-in. Cassegrainian telescopes produced by Tinsley Laboratories, Inc., Berkeley, Calif., a ruby laser, and a photomultiplier tube as a detector. A saturable Q switch is used to regulate the laser, which is being operated initially at 5 Mw.

ASTRONAUTICS

Surveyor's Condition Said to be Improving

Redesign of parts of the *Surveyor* soft-landing spacecraft is going along smoothly, JPL disclosed recently. The equipment compartments and retro-engine supports were analyzed as structures and redesigned; the housing that positions the solar panel and antenna failed during a lateral shake test and also is being redesigned. Failure of the spacecraft's shock absorber tubes turned out to have been caused by faulty manufacture; too much pressure was exerted by a machining chuck. Thermal problems posed by the lunar environment, said JPL, are still harassing *Surveyor* designers. Another comprehensive thermal test program is under way. Latest reports show that the spacecraft's thermally controlled compartments can dissipate excess heat at lunar noon and at night are now expected to lose only 20 watts heat instead of the 60 watts predicted earlier.

SPACE MEDICINE

Inflight Biochem Solution Analysis Needed

A novel apparatus for use in mixing reactant solutions for biochemical analyses in conditions of weightlessness will be tested by AF School of Aerospace Medicine scientists in F-100 aircraft. The assembly consists of a flexible tubing bent into a circle, into which the reagent is injected and mixed by rollers moving back and forth at each end. This device would be used in conjunction with a calorimeter cuvette. SAM doctors hope that such instruments can be developed so that in-flight measurements of urinary and serum calcium, urea nitrogen, creatinine and glucose can be made easily.

Confinement Tests Pressed by Air Force

Three important biomedical confinement tests important to manned space stations have been under way at various laboratories of the Air Force Aerospace Medical Div. The second in a series of tests of helium/oxygen environments for manned space stations was begun last week at the School of Aerospace Medicine. Four subjects will live in the space cabin simulator for five weeks, breathing a mixture of 56% helium and 44% oxygen at 7.34 psi pressure. Two others will live outside the simulator as controls. Also at SAM, work-rest schedules were tested in a 72-hour emergency simulation during the one-week confinement. At Wright-Patterson AFB, Ohio, Aerospace Medical Research Laboratories, four Ohio State University Students completed a six-weeks nutrition study for NASA, during which they subsisted entirely on a liquid nutrient diet.

Firm Creates New Motor Case Process

NTW Missile Engineering-developed roll-extrusion technique can form cylinders up to 156 in. in diameter from monolithic blanks

by John F. Judge

VERNON, CALIF.—A proprietary metal-working process reduced to practice in several pilot machines at NTW Missile Engineering, Inc., will eliminate most of the production problems in fabricating metal cylinders for defense applications.

The process, known as roll-extrusion, is applicable to all metals and alloys up to the refractories and has the ability to:

—Reduce or eliminate completely process scrappage. This means a substantially greater usage of metal delivered to the fabricator and almost total elimination of final machining operations on the configuration.

—Reach accuracies in dimensional tolerances far in excess of any similar metal working technique.

—Reduce fabrication time significantly, leading to an inherent high production ability.

—Increase both the tensile and yield strength of most metals during the forming.

—Incorporate integral stiffeners into the final configuration without resorting to any subsequent joining operation.

—Eliminate completely the need for welds in cylindrical parts up to 156 in. in diameter and 20 ft. in length. Or, if the starting blanks are welded, the process works the weld completely into the parent metal.

—Increase reliability and reduce both the cost and time for quality assurance procedures.

The roll extrusion technique is completely protected by patents and now exists in two horizontal machines and a massive vertical unit—the latter built and owned by the Air Force.

Frank E. Hooykaas, president of NTW, told MISSILES AND ROCKETS that even though the Air Force built the large unit, the firm's patent and proprietary data rights were properly protected by terms of the contract.

Roll extrusion is the brainchild of Mr. A. W. Ernestus, vice president of engineering, and he decribes the process as fabrication by compressive yielding.

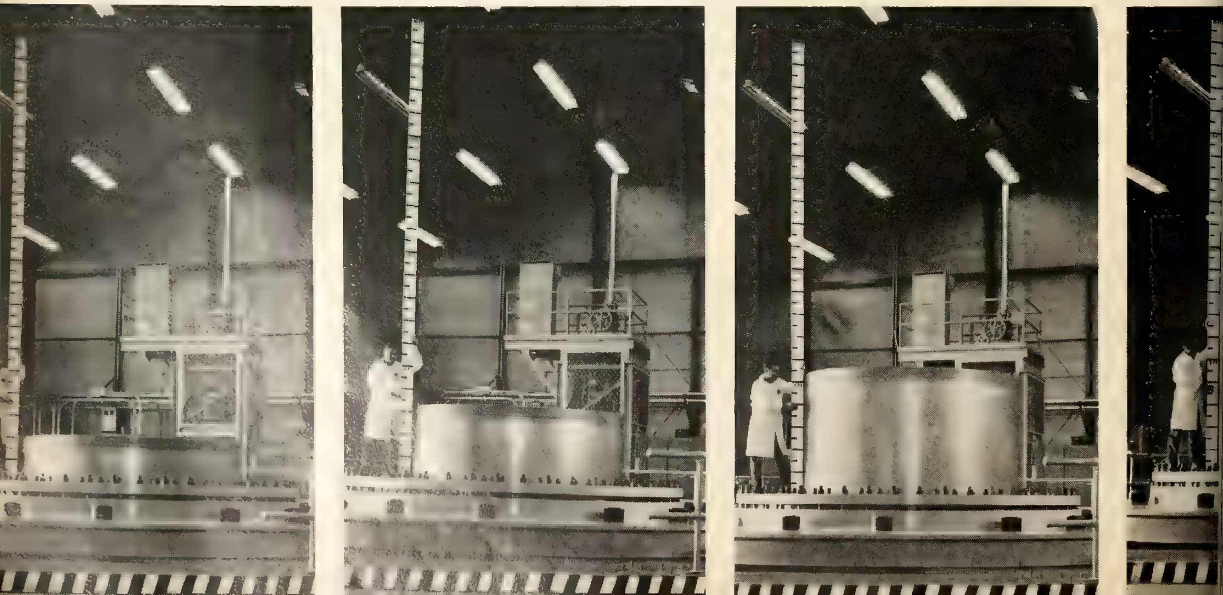
- **The 'green giant'**—In the large vertical unit, three rollers are mounted on a central shaft and positioned opposite a massive holding fixture enclosing the die ring. The work piece, normally a ring forging or a roll-and-welded ring blank, is gripped by a separate fixture.

The work piece rotates and is pulled downward while the rollers press the metal against the ring die. Pressure on the rollers is achieved through a wedge system so that each roller is forced against the work piece with the same pressure as the other two.

The huge green-painted machine can handle ring blanks from 90 in. to 160 in. in diameter and produce cylinders up to 20 ft. long. Each of the three symmetrically placed rollers can exert up to 1.2 million lbs. force against the workpiece and the pulling force is about 6 million lbs.

The unit was designed, built and is now being proof-tested under a $2.6-million contract from the Manufacturing Technology Div. of the Research and Technology Div., Air Force Sys-

ROLL-EXTRUSION machine extends 40 ft. into the ground. This series of photographs shows the roll-extrusion of a mild steel blank 120 in. across and 47 in. high to a finished cylinder 244 in. long. Wall thickness is reduced from 1.4 in. in the blank to 0.160 in. in the extruded product. The blank pictured was roll-and-welded. Photos were taken during second run of the



tems Command, at Wright Patterson AFB, Ohio.

NTW machined most of the component parts themselves, and the whole unit rests on the largest precision bearing ever built by Timken Roller Bearing Co.

Ernestus says the unit is designed on deflections rather than strength and the entire metal working operation is confined to the minute area where the roller forces the workpiece against the die ring. The surface finish of the die and rollers is extremely important and operating wear seems to be insignificant.

The two horizontal units can roll-extrude diameters up to 20 in. and all machines are more pilot production models than on-line production devices. All units can easily be rigged for production by adding normal machine tool controls.

- **Product performance**—By starting with monolithic ring forgings, the large roll-extruder has the potential to eliminate all welds in 20-ft. cylindrical configurations within its diameter ability.

However, tests on the devices have shown an innate ability to work welds so completely into the parent metal that roll-and-weld blanks pose no problems. One interested aerospace firm took several days and their best metallurgist to find the original weld in a roll-extruded sample.

In addition, the brutal working of the metal tends to reveal major flaws during the fabrication cycle. In fact, it may be possible to cut out the flaw, weld in a repair piece and run the entire configuration back through the roll extruder—working the weld into the parent metal.

Production time and cost is considerably less than following the roll-and-weld approach to large cylinders—such as the 120-in. rocket motor case. This has not yet been completely demonstrated, but the current proof-testing of the machine under Air Force funding might help—the diameters involved are 120 in.

- **Machining depth**—Hooykaas is experienced in the various metal working processes known as "chipless" machining. These includes metal spinning methods such as Floturn, Hydrospin, Spin Forge and others. The basic idea here is to form metal against a mandrel by rollers.

One of the simplest configurations produced on such equipment is the straight cone—where the metal flow from a simple disc blank is governed by the sine law. Contoured shapes are more difficult.

Hooykaas says the shear-spinning of tubular shapes from ring blanks over a mandrel does not displace metal in accordance with the "shear" principle of the sine law—as in cones—but depends on forces developed in the axial and radial directions.

The pressure rollers must bite into the material and produce a stretch or gathering simultaneous with the reduction of wall thickness to maintain control over the diameter and wall thickness.

These forces may be of such magnitude, says Hooykaas, that the part may tear during the operation. There are many modifications being worked into such equipment—expecially in roller numbers and control. But, while minor variations in wall thicknesses can be made, integral stiffeners such as ribs and flanges must be attached by welding, riveting and bolting—adding both weight and cost to a given part.

- **Spinning control**—The single roller is the preferred method with respect to external pressure roller methods. But the enormous forces required create problems in the deflections of both mandrel and machine spindle.

Dual or triple roller arrangements in the vertical or horizontal position involve an essential balance of forces, but Hooykaas says the exact equalization of these forces is difficult to obtain. This is because any minor variation in the hydraulic or mechanical movement of the rollers can cause rupture in the part.

Roll extrusion solves all of these problems with regard to cylindrical shapes. NTW has a significant investment in spinning equipment and these machines can be used to complement the roll extruders.

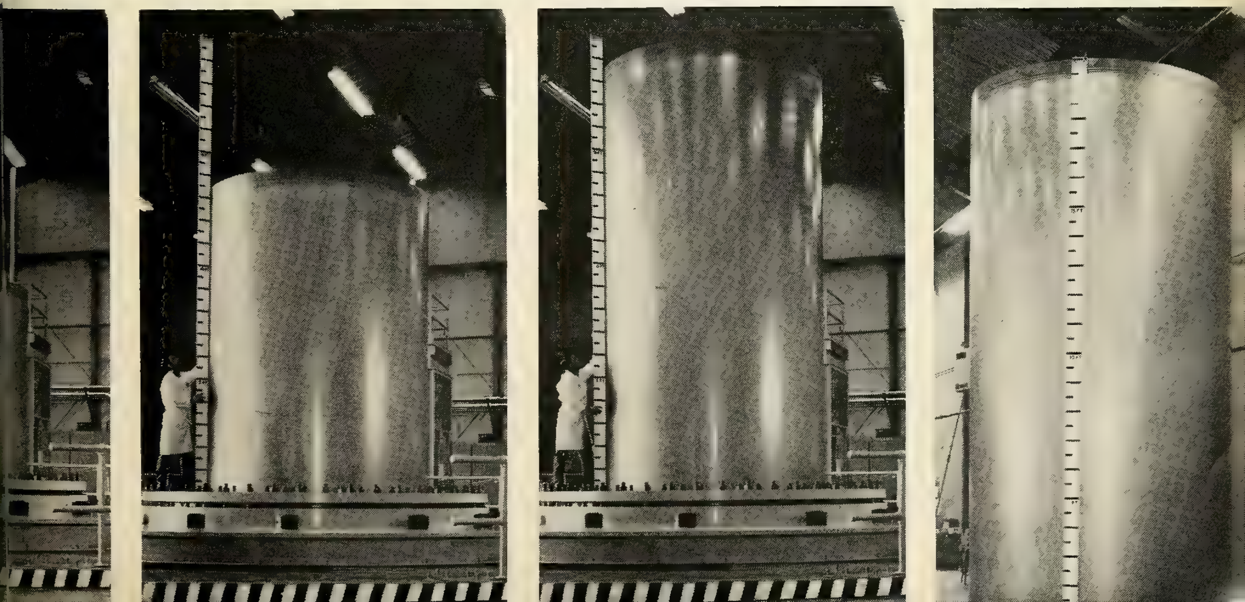
The concept can easily be applied to existing machinery designs—such as lathes. This reduces the cost of building up an inventory of roll extruders for major production runs.

- **Contract areas**—NTW is dealing with all three military services—the Air Force on the machine itself and its products, the Navy on torpedo casings and the Army has examined an NTW proposal to use roll extrusion for the fabrication of *sprint* missile launching tubes.

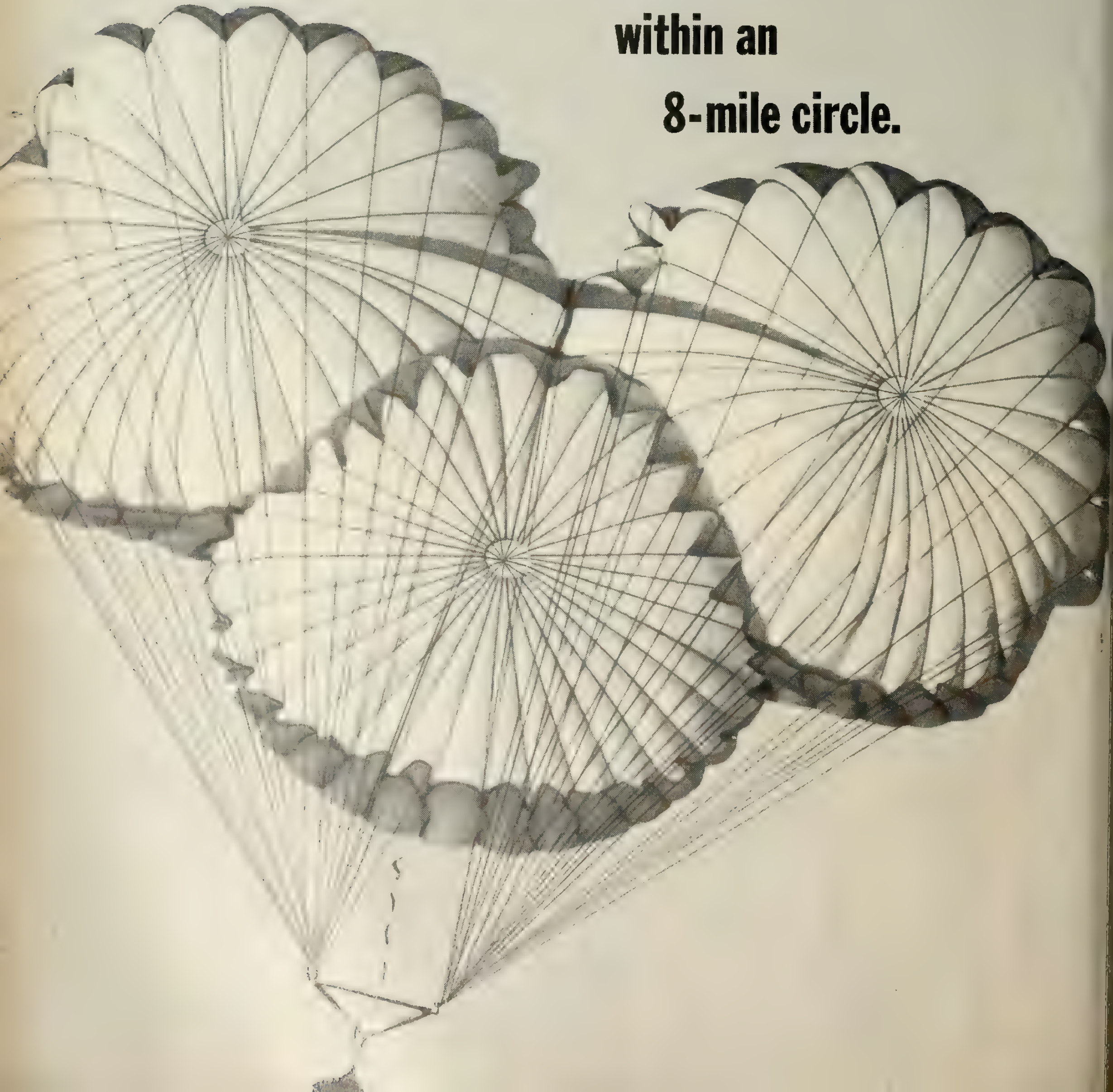
The Navy work involves the manufacture of integrally stiffened tubular structures for evaluation purposes.

NTW has received a pilot run contract from Rocketdyne Div. of North American Aviation to produce a limited number of oxidizer and fuel tanks for the *Lance* missile. These are aluminum tanks 20 in. in diameter and 40 and 60 in. long. ■

160-in.-dia. machine. NTW can easily neck-down the machine by replacing the ring-die and roller head to accomodate both Minuteman and Polaris solid motor stage case diameters. The workpiece shown required six downward passes, but a higher strength steel would be easier to work and its surface finish would be smoother. Each pass takes only minutes to complete.



This is a new kind of recovery parachute called the Cloverleaf. From 10,000 feet it can be steered to any landing spot within an 8-mile circle.



The three-canopy Cloverleaf has repeatedly demonstrated that it will glide more than two feet horizontally for each foot of descent. Its variable glide ratio and ease of steering give the controller plenty of time to guide it to a gentle landing on a selected spot.

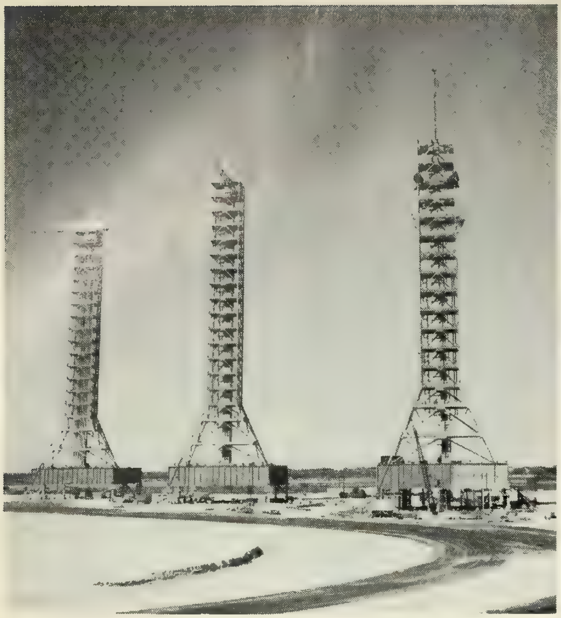
The Cloverleaf can be controlled from the ground or from an aircraft. It can home in on a beacon.

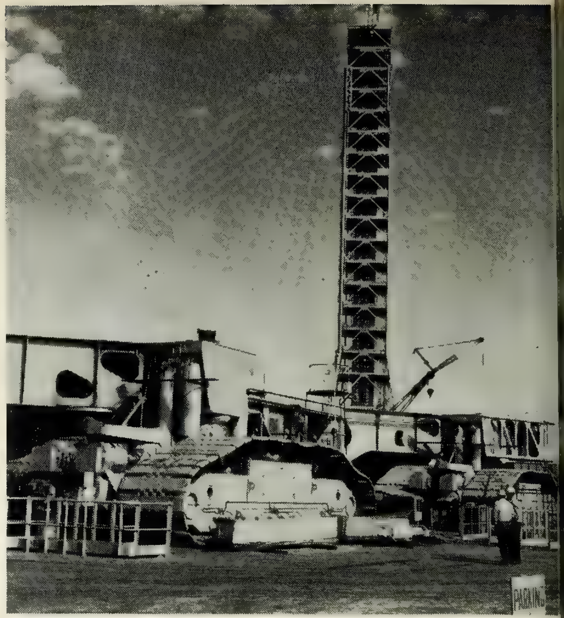
This new concept in parachute systems gets its high performance from low-porosity canopy material, pointed leading edges, double flaps for glide and turn control, and the high aspect ratio of the three combined canopies.

The Cloverleaf has been developed with support from the U.S. Air Force and the National Aeronautics and Space Administration. It points the way to fully controlled land recovery of large space vehicles and boosters, the pinpoint landing of air-dropped supplies, and the controlled landing of high-altitude instrument systems.

The Cloverleaf concept grew out of the continuing research in paradynamics carried on by Northrop's Ventura Division. Northrop Ventura has developed the parachute landing systems for NASA's Mercury, Gemini and Apollo programs.

NORTHROP





space support

MILA Construction Delays Cramping Space Agency's Launch Schedulers

by Michael Getler

Merritt Island, Fla.—NASA project managers at the John F. Kennedy Space Center here, responsible for readying the 87,000-acre Merritt Island *Saturn V/Apollo* launch complex in time for the first *Saturn V* flights in early 1967, are becoming increasingly concerned about construction delays.

NASA says delays caused by labor problems, site modifications, and some construction deficiencies have pushed contractor time-to-completion dates beyond original estimates—as much as 25% in some cases. Project managers report that strikes alone have cost the space agency about a month's working time in the past year.

While NASA has not yet formally pushed back its so-called "need date" for the facilities, officials say that unless the critical time factor is reduced from this 25% growth in contractor deadlines, some slippage is likely in the NASA objectives. Planners here are working at keeping schedules closely coordinated in order to avoid paying a penalty for "having some things ready too soon."

NASA says the stretchout in readying the site, in terms of contractor dates, is actually running considerably ahead of cost increases for the unique complex. The cost figures are now pegged at about 10% beyond the original estimates.

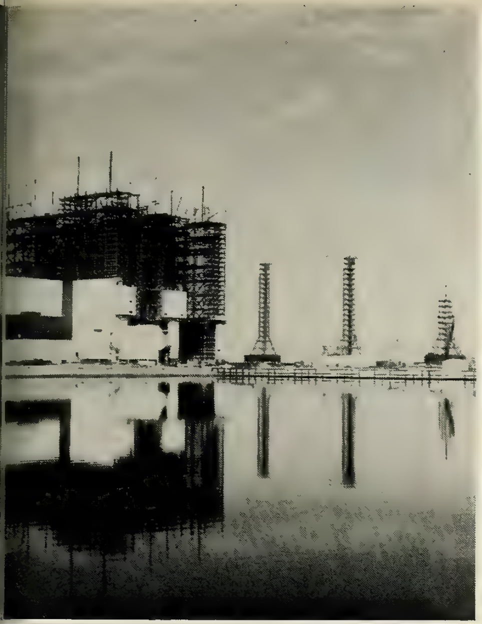
- **Taking shape**—Despite the delays in some areas, considerable progress is visible at both major portions of the $750-million space center, and engineers report no technical bottlenecks.

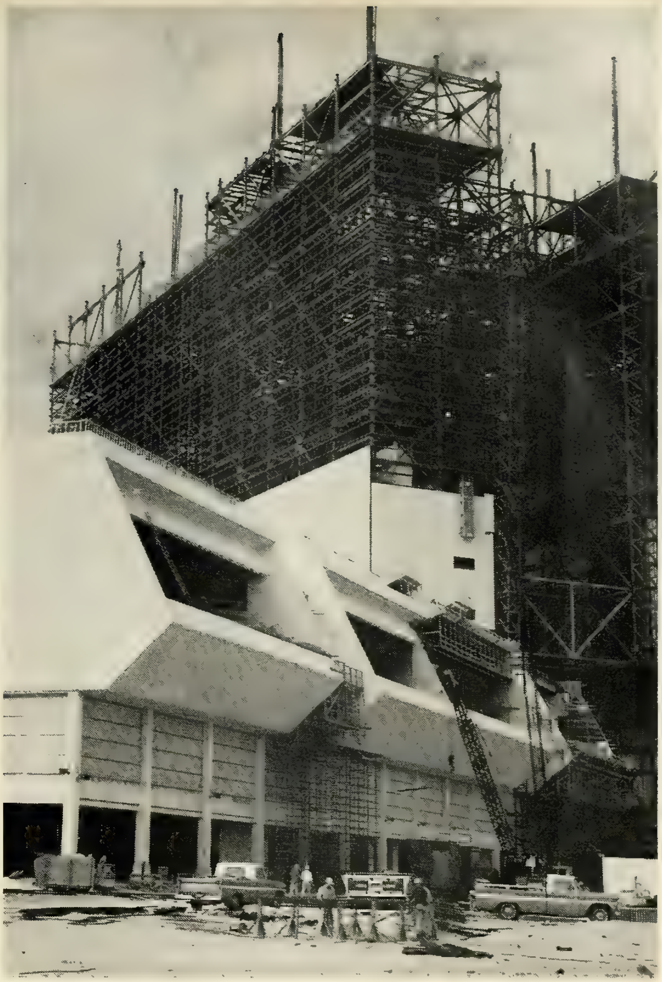
At the heart of the Merritt Island Launch Area (MILA), the $400-million Launch Complex 39, engineers are hopeful that erections of structural steel for the 525-ft.-high Vertical Assembly Building (VAB), where the *Saturn* booster and *Apollo* spacecraft will be mated, will be completed in May. Workers have now put up 49,000 of the total 57,000 tons of steel which go into the mammoth $100-million structure.

Topping off the VAB will allow NASA, and the Army Corps of Engineers (which supervises construction for the space agency) to proceed into another key timing phase—installation of the concrete roof and 250-ton bridge crane. Once this is in place, it will allow construction of the multi-level work platforms which will encircle the complete *Saturn* vehicle in the high bay work areas.

NASA hopes to have Bay 1 of the four vehicle assembly bays ready for "beneficial occupancy" in July. Planners hope to have the VAB, with Bays 1 and 3 operational, ready by mid-1966 in order to start tests with the *Saturn* 500F checkout vehicle now being put together at MSFC.

This non-flight booster will be used to run operational tests on the VAB bays, mobile launchers, crawler-transporters and other launch-associated





CONSTRUCTION PROGRESS at MILA. FAR LEFT: Complex 39 mobile launchers #1, 2 and 3 from camera tower to east. LEFT: Crawler-transporter side 2 at the complex. ABOVE: Reflection shot of Vertical Assembly Building, Launch Control Center and Launch Umbilical Tower from east side across turn basin. RIGHT: North side of Control Center.

equipment. The 500F sequence at Complex 39 will take 116 days, including 49 days in the VAB, 60 days on the launch pad, and the remaining days back at the VAB for disassembly.

NASA likewise hopes to have Bay 2 activated by the time the actual *Apollo* lunar landing shot is attempted, and possibly Bay 4 at that time. However, only Bays 1 and 3 will be required to handle the earlier phases of the program.

The low bay area at the complex, which includes eight smaller preparation and checkout cells for *Saturn* upper stages, is now fully enclosed, with the S-II and S-IVB stage platforms in place. The area is expected to be ready this spring, with a computer slated for installation in late June or early July.

In another major project at the launch complex, two of the three 400-ft.-high mobile launchers, on which the fully assembled *Saturn* will be mounted and moved intact to the launch pad, are reported now structurally completed and work on the third is about halfway to completion. These units, when fully equipped, will cost about $20 million each.

- **Big movers**—Engineers also report that the first of two crawler-transporters, which are being built on the site, "will be moving this month." These unique movers, which cost just over $5 million each, and weigh 5.5 million lbs., will be used to transport the entire unfueled *Saturn/Apollo* vehicle and the mobile launcher down a specially designed 3-mile-long "crawlerway" to the launch pad.

Total weight the crawler will carry to the pad is about 12 million lbs. The tracked crawler, which can move at flank-loaded speed of about 1 mile per hour, is actually expected to take several hours to make the trip to the pad. The road upon which it will travel, now nearing completion, is designed much like airport runways and uses a crushed limestone base. It can support 18 million-lb. loads.

Of the two launch pads at MILA where work is going on, pad A, the southern-most of the two, is now about 80% complete. Work is just getting under way at Pad B.

In other work at Complex 39, NASA reports that the 1,200-ft.-wide barge terminal point, or turning basin, where the large first stages will be recieved, should be completed by September, long before it is actually needed. Also, the complex's Launch Control Center is expected to be available for initial occupancy by the space agency this summer.

Of the two key structures in the MILA indutsrial area, the Manned Spacecraft Operations and Checkout Building is the first to be completed and has already expanded. About 500 persons are working there. The adjoining headquarters building is expected to be ready in May. ■

Celestial Simulator is Major Advance

Facility being tested by Air Force has capability to evaluate stellar-inertial guidance systems for extended space flights

HOLLOMAN AFB, N.M.—Tests of an advanced celestial simulator are underway at the Central Inertial Guidance Test Facility (CIGTF) of the Air Force Missile Development Center here.

Intended for calibrating star trackers and stellar inertial navigation systems, the $2-million simulator provides a −2 to +5 visual-magnitude single G-type star, positioned to an accuracy of 1.5 arc seconds in 1 degree steps. A range of 33 artificial monochromatic stars is also available.

Double G-type stars can be simulated, with varying separations and relative intensities. These doublets can be provided with sky backgrounds between 5 and 500 candles per sq. ft., with variable brightness gradients and polarization.

• **Good start**—The new facility represents the first major step in a CIGTF program to develop a capability to evaluate stellar-inertial systems. These systems correct inertial guidance platform drift by means of celestial-body or fixed-star tracking, providing the accuracy needed in extended space missions. (In a lunar mission, for example, an uncorrected gyro drift of 0.0005° per hour can lead to a target miss of more than 100 miles.)

Describing the simulator, Edgar B. Godley, celestial-inertial engineer at CIGTF, said that Keuffell and Esser Co., the optical contractor, had pushed forward the state of the art by achieving a diffraction-limited star subtending only 2.5 arc seconds.

Originally, CIGTF requested a 1-arc-second star; it still hopes to get down to this within two to three years in a more advanced installation—the proposed "hybrid" complex, for which AC Spark Plug received a $250,000 design contract.

Early planning at CIGTF also called for moving multiple star and planet images, but this turned out to be beyond industrial capabilities—given the accuracies required and the funds available for the first installation. Images of every type of star known, covering the spectrum from ultraviolet to infrared, together with the Sun and Moon, were wanted.

Broad capabilities of this sort are proposed for the hybrid complex at Holloman. This will have a 60x197-ft. main building containing five large "Class 100" seismically stable laboratories. Support features will include an optical bench room 10x180 ft., and a mile-long underground optical tube. The facility should be capable of simulating nearly every type of natural and man-made wave propagation. Natural celestial bodies also will be tracked.

• **Good for present**—However, the present simulator, for which the Kearfott Division of General Precision Inc. was the main contractor, appears "more than adequate for most tracker systems under development," said Godley. "Although this celestial simulator was built within the limitations of the state of the art of 1962, we believe we have the most sophisticated and advanced celestial simulator in the Free World, and that it will serve industry and the government well for some years to come."

The availability of monochromatic beams in steps of 0.02 micron in the range of 0.35 to 1.0 micron, double stars, and variable amounts of polarized light in the background, enable tests of the discriminatory powers of trackers. Some of these are designed to identify stars by color; others pick out double stars by reference to their angular separation. One design uses the polarization of sky background light to guide it to the star it tracks.

The simulator's available background of 500 ft. Lamberts (graduated from zenith in brightness and polarization) represents a fairly bright sky. Already, however, one Air Force tracker needs testing at a higher level.

The mechanical and optical components of the simulator are housed in a 37-ft.-square, 14-ft.-high room. This has given a total particulate count of less than 5,000 particles (0.32 micron and larger) per cubic foot with as many as six people in the room. Eventually the simulator is likely to operate in an environment better than an "AF Clean Work Station".

The celestial simulator components in the room are mounted on a central seismic block 16 ft. square—250,000 lbs. of monolithic reinforced concrete. Digital data-processing, control and programming systems are located in a control room outside of the clean room.

• **In operation**—True position of components on the block is obtained from a porro prism device mounted on it. Using a Wild T-4 theodolite, first-order sightings of Polaris are made through a 20-inch optical flat in the clean room ceiling. These sightings, preferably at elongations, can be transferred simply by plunging the theodolite some 40° to one of the porro prisms. The calculated heading of true north is then transferred to the second porro prism by means of the T-4, which always remains fixed over a geodetic bench mark maintained in the clean room.

A single-axis table holds the inertial guidance system under test, together with theodolites, autocollimators and other calibration instruments. Originally, a capability of testing trackers at various rates other than Earth rate was hoped for. This turned out to be beyond the state of the art. The 48-in.-dia. table therefore remains fixed in position during measurements. It can carry a 500-lb. load, and runout or wobble of the horizontal surface is held to ± 1 arc second. Azimuth angle is sensed by a 720-pole inductosyn to an accuracy of about 1 arc second, positioning being carried out from a remote control console.

Two attachments to the base of the positioning table play an important role in accurately locating the angular position of other elements of the simulator. A master angular reference (MAR) mounted on an integral arm of the cast table base provides the optical position reference for the single-star beam, to within ± 0.25 arc second at one degree increments. A master mirror assembly on the opposite side of the table base references the position of the double-star beam.

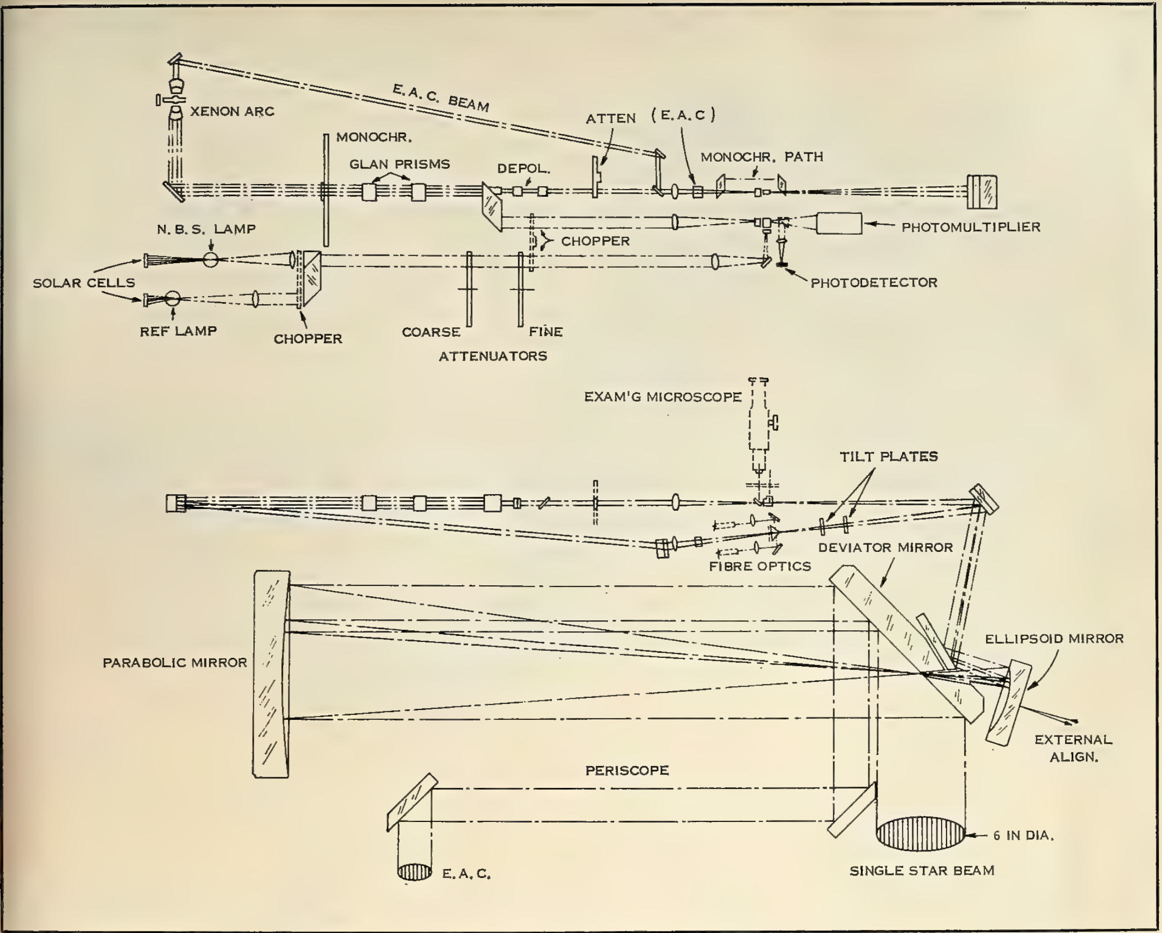


DIAGRAM OF advanced celestial simulator being tested by Air Force.

The single star beam emerges from a massive overhead fixture that rotates about a horizontal east-west axis. This moves the beam through 190° in elevation in the north-south vertical plane. The dual star beam emerges from a stationary fixture on the opposite side of the table. This beam is on the west-east axis. One star is fixed at 25° elevation to the horizontal. The second star of the pair can be continuously positioned in the vertical west-east plane up to 4° from the first.

- **Intersection**—The axes of simulated star beams and the optical axes of the tracker under test must intersect at the complex optical center. This is located at the intersection of the table axis and the axis of rotation of the single star fixture—5 ft. above the seismic block and 30 inches above the table top surface.

A xenon arc source, optics, filters and attenuators within the rotating overhead fixture generate a diffraction-limited star. The star image subtends an angle of 2.5 arc seconds within a 6-in.-dia. collimated beam. A brightness control system maintains desired star brightness to 0.1 visual magnitude by means of a closed-loop system error-referenced to a National Bureau of Standards tungsten lamp.

From the back of the xenon source a second beam originates, to be collimated by the same optical elements as the single star beam. This is the electronic autocollimator (EAC) beam. It has a fixed spatial relationship with the star beam and is used to position the star beam perpendicular to the master angular reference (MAR) to within 1.5 arc seconds.

The EAC also enables the star to be precisely moved up to 20 arc seconds in either of two degrees of freedom relative to the nominal position established by the MAR.

A monochromator attachment, using dichroic filters, enables an artificial monochromatic star to be projected. Total range of the light output of the instrument is 0.35 to 1.0 micron. Each monochromatic beam nominally peaks every 0.02 micron over this range, the half-bandwidth of each filter not exceeding 0.015 micron.

- **Positioning**—The dual-beam star simulator also makes use of an electronic autocollimator system, to drive each of the star beams to perpendicularity with respect to the appropriate reflecting surfaces on the master reference mirror assembly.

By changing the position of the movable master mirror, the movable star can be positioned from coincidence with the fixed star to a separation of 50 arc seconds, with an accuracy of ± 1 arc second. At greater separations the error is ± 2% of separation; it never is greater than ± 1 arc minute.

The sky background provided for the double stars is uniformly diffuse like the sky, and has a spectral distribution similar to that of a 9,000°K black body. Not only can its brightness be varied from 5 to 500 candles per sq. ft. but the brightness gradient can be varied in five steps. Also the sky brightness can be varied as a function of time and the polarization can be adjusted to any angle. ■

Ampex guarantees:

these premium A&B oxide tapes will make standard bandwidth instrumentation recorders perform better.

If that doesn't surprise you, this might: now you can buy the long-wear, heavy duty Ampex tapes at standard, regular-wear prices. No recorder—old or new—will give maximum performance if you're using run-of-the-mill tape. Now you can forget about making do with ordinary tapes because of cost limitations. You can buy premium, heavy duty Ampex A and B oxide instrumentation tape—guaranteed to deliver optimum performance on most recorders—at standard, regular-wear tape prices. Ampex A and B oxide is not only long wearing, it gives you better short wavelength response than standard tapes. It's not only conductive and anti-static, it's cleaner running than standard tapes. It not only reduces head wear and dropouts, it gives you more uniform output and higher resolution than standard tapes. Ampex tape and standard tapes really have only one thing in common: their price. Order today, or write Ampex Corp., Redwood City, California, for full details.

INSTRUMENTATION
AMPEX MAGNETIC TAPE

© AMPEX CORP. 1965

AMPEX

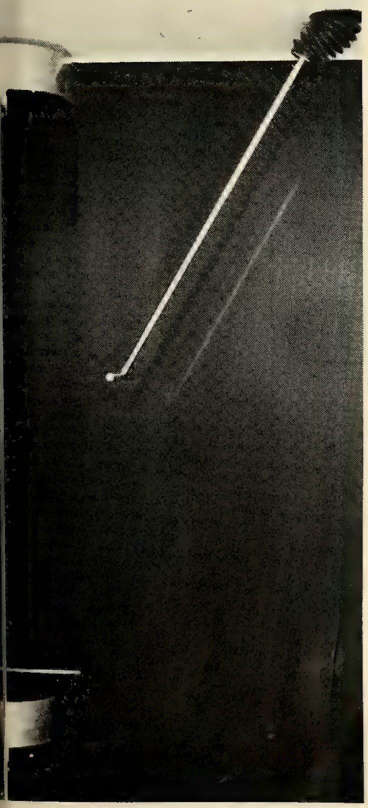
Circle No. 5 on Subscriber Service Card

Drugs Studied To Aid Astronauts

Work funded by National Institute of Mental Health induces disorientation similar to that encountered in space missions

HALLUCINOGENIC DRUGS to rain astronauts so that they will be able to function although disoriented by space travel are being studied by a scientist at the Albert Einstein Medical Center in Philadelphia.

Working under funds from the Naional Institute of Mental Health, Physiology Department Chief Dr. Leonard Cohen is experimenting with primates on the effects of the drugs known as LSD, Sernyl and Ditran. The work differs from that being supported by NASA at the Naval School of Aviation Medicine under Dr. Ashton Graybiel (M/R, Aug. 31, p. 26) in that drugs are being used which actually produce similar symptoms to space disorientation rather than drugs to counteract it.



ACTIVITIES of monkey under the influence of hallucinogenic drugs are recorded from outside special animal chamber in which primate is confined at Albert Einstein Medical Center. Monkey's behavior is filmed with a 16-mm Kodak Reflex special camera focused through one-way glass into chamber. Film record allows researchers to make precise comparisons of behavior with different combinations of drugs and surgical modifications that simulate stages of disorientation that could occur in astronauts during space flight.

Cohen told MISSILES AND ROCKETS that the drugs look very promising as a means to expose astronauts to the sensations they might encounter when removed from gravitational cues. He suggested that they could thus be familiarized and trained to increase their resistance to disorientation and motion sickness.

- **Testing methods**—An elaborate primate testing room was constructed containing various devices such as a vertical ladder, a swing that can be motor driven at constant speed for free-swinging, a vertical pole, a vertical peg climbing board in which the arrangement of the pegs can be varied, and adequate floor space for walking.

By rewarding the animals with food, Dr. Cohen can induce them to perform given tasks before and during the influence of drugs. Some of the test animals—monkeys and baboons—are surgically modified so that the normal gravity-and-motion-sensing organs are removed. Their performance is monitored by a 16-mm Kodak Reflex special camera with Eastman Tri-X reversal film, type 7278. The use of this film record provides a precise means of comparing their behavior in each situation, removing the previous subjective analysis by the experimenter.

- **Different approach**—The work has led Dr. Cohen to an interest in the nerves of the neck as being the seat of gravitational sensory input, rather than the vestibular organs being studied by almost all researchers in the field of disorientation.

Cohen said he has found that primates that have had the first three pairs of dorsal nerve routes in the neck severed show severe disorientation. In clinical studies also, he said, it has been found that people with muscular strain or trauma to the neck or shoulder region sometimes have this disorientation as well. Most literature on disorientation ascribe the condition to the organs of the inner ear, specifically to the "hairs" of the semicircular canal.

Should it be found that the neck prioreceptors are equally important, it will be necessary to revise thinking on how to aid astronauts in coping with possible "space sickness." Although simple weightlessness is not expected to cause great difficulty, the combination of accelerations and movements will require remedial action, especially in the case of a rotating space station.

Cohen hopes to get a qualitative answer to the question of whether neck or vestibular phenomena cause disorientation with the aid of these drugs. He feels that by giving the drugs to an animal with the neck sensory mechanisms removed, he may get some clues. If the animal, already disoriented by the loss of the nerves, is further disoriented by the drugs, it will indicate that the drugs have acted upon another mechanism. If it does not complicate the effect, it may mean that the neck was to blame. The same principle would apply in testing labyrinthectomized animals.

- **Agreement**—Both schools of thought—neck vs. ear—agree that whatever the cause, training will help. With the use of the drugs, Cohen feels, a qualitative analysis can be made of the effect. And one of the big hazards to the astronaut—fear of the new sensation—would be removed before he went into space. ■

Analog, Digital Computer Combination Will Aid in MOL Mission Simulation

SUNNYVALE, CALIF.—A combination of analog and digital computers that will drive several independent simulators at the same time on-line is nearing readiness in the crew system simulation function of Lockheed Missiles and Space Co. here. The digital machine will also serve the computation needs of other bioastronautics functions at LMSC.

To start with, the computer system will be used with a 30 ft. by 10 ft. space simulator of *Manned Orbiting Laboratory* (*MOL*) configuration, accommodating a crew of two. All systems in the simulator are being sized, however, to have sufficient capacity for a four-man crew.

In space stations of this type, the astronauts are in a closed container, and, apart from looking out a window, interact with the outside world through a multiplicity of controls and electronic displays. For the Lockheed simulator, the computer system acts as the link between the controls and the displays, making the instruments show the space station and its systems responding in the same way as they would in space. The computer system will also control the apparent movement of optically simulated star fields, Earth, and a target vehicle.

The computer system has the advantage of being easily programmed to simulate the characteristics of any space station, and can match the growth potential of these stations for manned interplanetary missions.

It has the added advantage that it cannot only interact with the men in the space station but also collect and analyze information about their performance.

• **Part of STARS**—The computer system is one of the major pieces of hardware in the company sponsored STARS program (System Test and Astronaut Requirements Simulation). Other hardware items include the space station simulator—a sealed container with a completely artificial two-gas sea-level environment, built up from prototype space equipment modified for a gravity field—and the optical simulator.

When simulating a star field, the optical simulator will provide 400 stars of four different magnitudes, positioned accurately enough for manual star-sighting, and with correct color temperatures for star field identification.

An 18-ft.-dia. environmental chamber to provide the spacecraft with a vacuum environment is scheduled to start building in March.

Lockheed has invested $3 million in its entire bioastronautics program, of which STARS is an appreciable part. The company is very serious about getting into the man-in-space business, aiming at the in-space phase rather than the ascent or descent phases.

Activity at Lockheed is broken into the following functional areas: human factors, where most contracts are; biomedical research, carried on in a new part of the Research and Development Division, Palo Alto; crew monitoring; life-support system engineering; and crew systems simulation, which builds hardware and operates it in response to requirements of the other life sciences.

All these functional areas are part of the Research and Development Division, reporting to the division's Director of Engineering. Although this arrangement is unusual, it stresses Lockheed's belief that analysis of astronaut requirements and performance is a legitimate concern of engineering design.

• **Broad application promised**—By use of time-shared programming, the digital computer in the STARS hybrid computing system will eventually be available to all areas of research in bioastronautics. It will serve both as a component for a number of independent simulator systems and as a data reduction tool. The machine installed is a Control Data Corp. 3200 model.

An analog computer has been linked into the system to provide the rapid response to control movements typical of spacecraft. Violent attitude changes beyond the dynamic response capability of the digital machine will be handled by up to four PACE 231 R analog computers made by Electronic Associates, Inc.

The end of the violent maneuver yields the initial conditions for a digital computer program, which computes and continuously updates their effect on other spacecraft systems. The vehicle normally will have slightly imperfect stability, changing attitude very slowly, with small corrective actions taking place every 15 minutes. This small, slow change will be handled by the digital computer.

• **What it will do**—Typical tasks for the computer when operating with the main simulator will be to solve equations of motion and of space kinematics. It will also carry out a great deal of logical analysis followed by display generation, in situations where ensuing states of the system are a complex function of multiple control actions.

For example, the computer will adjust the environmental control system to respond to the switching in of redundant units. If a lithium hydroxide bed is changed, the computer will re-adjust the indicated rate of change of CO_2 content in the space station. Another example is simulation of transmitter warmup. This requires a table look-up program for the required warmup curves. The type of curve can be changed to take account of changing power supplies or transmitter tubes, and the system can be programmed to fail in any way that the experimenters want it to fail.

In other tests, an experimenter might program a fault that consists of a drastic change in main rocket thrust alignment. The ultimate aim is to have a real-time analysis of the man's response to changes of this type to get some idea of how well he is doing. The simulated mission may be altered as a result of such indications. Real-time analyses of this type depend heavily on statistics—such things as the analysis of variance and covariance—and the availability of a computer is important in making real-time analysis a feasibility.

Other functions carried out by the computer will be calibration routines. Many of the experimenters will want to see information from the system not as a voltage but as units of their particular interest—degrees Fahrenheit, for example—and table lookup routines will again be involved.

- **Simulation prime concern**—The method of linking the machine to the simulator is based on achieving good simulation rather than striving for maximum computer utilization. The entire system has been designed for time-shared operation with several simulators that have no relationship or with computing consoles that might be running independent analyses for a laboratory. From the point of view of the users, they are being serviced on-line.

The aim of the system is to ensure that a user is not aware of a computation period interposed between his control actions and the response of the simulated spacecraft. In fact, the computation delay is generally less than seven milliseconds.

To get a good display and realistic simulation, very good dynamic response (fast movement) and long term accuracy (high dynamic range) are needed together. In addition, the simulation must be capable of ready adaption to meet changing space station concepts.

Dr. R. L. Martindale, STARS Program Assistant Leader, explained that only a programmable general-purpose system could give the flexibility of simulation and response desired. The simulation system, however, presented special problems in using a computer, because the input-output devices must reflect problems of the real world. Such devices are quite different from the conventional punched-card or tape readers and output printers, and often do not go well with a computer.

Typically, a continuous input in a simulated spacecraft might be some form of stick control, and the computer must be bent to the nature of this type of input.

- **Abundance of channels**—Another feature of the system is the large number of input-output channels with low bandwidth requirements. There is rarely more than a 20-kc rate between peripheral equipment and the computer, but there are thousands of channels under control, system engineers emphasize.

"We feel that we have come up with a design of input/output device that accommodates the whole range of types of signal that are likely to be generated," says Martindale. "To ensure that the displays and controls interface well with the computer, we have developed the Simulator Control and Data System (SCADS). This is the link between simulator-type language and computer-type language."

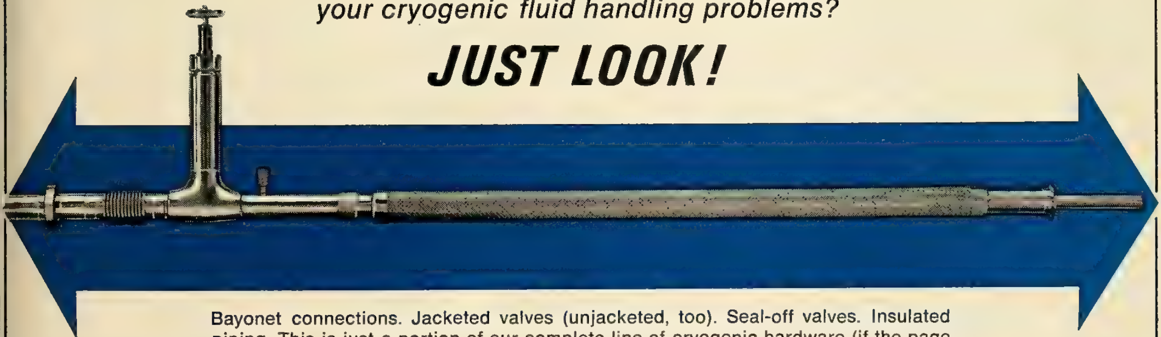
The simulator language has been selected to be particularly appropriate to crew systems simulation. The actual inputs in this language, however, are characterized by a great deal of redundancy. So as well as performing language conversion, SCADS removes redundancy from the information transmitted.

There are three different modes of data compression for analog data, and a multiplexer can sample randomly at any rate up to 20 kc. Mostly, however, individual channels are working at 200 cps or less.

A large part of the input information is event data—indicating a switch pushed, a change in valve position, and similar actions. A pulse coding system is used for these data. ■

What has CryoVac done to solve your cryogenic fluid handling problems?

JUST LOOK!



Bayonet connections. Jacketed valves (unjacketed, too). Seal-off valves. Insulated piping. This is just a portion of our complete line of cryogenic hardware (if the page were wider we could show you more) we think will help solve your cryogenic fluid handling problems. ☐ Our engineers were unable to find commercially available components that would meet the exacting specifications necessary for our cryogenic transfer line systems. As a result they developed this complete line of proprietary cryogenic hardware. It solved our problem. And as we said, we think it will solve yours, too. Why not find out for yourself. You can by writing and asking for complete information on our cryogenic transfer line systems.

cvi ®
CryoVac
INCORPORATED
COLUMBUS 12, OHIO

Circle No. 6 on Subscriber Service Card

LET'S SWAP RESUMES

New programs ranging from microminiature circuitry to complete manned spacecraft design and production have created many openings in Design and Electronics through the Managerial level. Experienced men are needed for such programs as GEMINI • PHANTOM II • ASSET • STOL TRANSPORT • CAPSULE ESCAPE SYSTEMS • BOOST-GLIDE REENTRY VEHICLES • PHOTO INSTRUMENTATION EQUIPMENT & SYSTEMS • AIRFRAMES & ENGINES • ELECTRONIC SYSTEMS & EQUIPMENT.

DESIGN

Experienced designers and layout engineers are required for positions in:

AIRCRAFT STRUCTURE • MECHANICAL SYSTEMS • STRESS, LOADS & WEIGHTS • AERODYNAMICS • LAYOUT • PROPULSION • ELECTROMECHANICS.

ELECTRONICS

Experienced and mature engineers of management calibre are required for positions involving concept design, analysis and development of electronics equipment in areas of:

MICROELECTRONICS • COMPUTERS & AUTOMATION • SPACE INFORMATION SYSTEMS • SURFACE COMMUNICATIONS • TRAINERS & SIMULATORS • PROCESS CONTROLS • AUTOMATED CHECKOUT • BIOMEDICAL SYSTEMS • ASW • NUCLEAR STUDIES • ECM & ECCM.

McDonnell's educational assistance program plus the convenience of nearby St. Louis and Washington Universities are additional incentives to select McDonnell for your career.

To arrange convenient interview, please complete the attached coupon. All information will be confidential.

MCDONNELL, P.O. Box 516, St. Louis, Missouri 63166
Att: W. R. WARDLE, Engineering Employment Office, Dept. PP-315

Name________ Home Address________
City & State________ Phone________
Present Position________
Primary Experience Area________ No. of years________
Education: AE____ ME____ Math____ Physics____ Chemistry____
EE____ Bus. Adm.____ Other________
Degree: BS____ date MS____ date PhD____ date

MCDONNELL
An equal opportunity employer

St. Louis Bicentennial Space Symposium and Fifth National Conference on the Peaceful Uses of Space, May 26-27-28, 1965
For information, write: Box 7133, St. Louis, Missouri 63177

Circle No. 8 on Subscriber Service Card

The Industry Week

New Activities

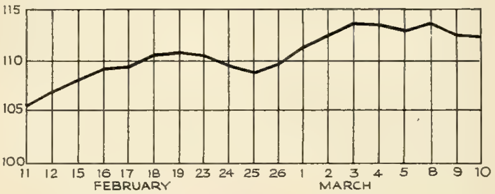
Avco Corp.'s Research and Advanced Development Div., Wilmington, Mass., has created two new assistant general manager positions in a move to keep pace with the firm's rapid growth in space systems work as a field distinct from missile systems. Named as vice president of missile systems is Dr. R. W. Detra; vice president of space systems will be Dr. J. A. Kyger. Avco president E. D. Kenna explained the change by observing that over the last two years space systems work has been growing rapidly, and that the technologies called for have been diverging from those for missile systems. The two assistant general managers will direct their own marketing and business management departments. . . . *The 3M Co., St. Paul, Minn., has consolidated its activities in the magnetic tape recording field into the newly formed Revere-Minicom Div. Products of the new division will include Mincom high-performance magnetic tape instrumentation recorders used by the military and aerospace industry and the Wallensak line of broadcasting and motion picture tape recorders. Manufacturing facilities of the division are located in Chicago and in Camarillo, Calif.* . . . The Franklin Institute, Philadelphia, has renamed its Philadelphia research and development division The Franklin Institute Research Laboratories. Formerly known as The Franklin Institute Laboratories for Research and Development, the division specializes in the fields of chemistry, physics, electrical and mechanical engineering, operations research, and nuclear and aerospace engineering.

Mergers and Acquisitions

Chicago Aerial Industries, Inc., Barrington, Ill., has broken off negotiations with Itek Corp. through which Itek had planned to acquire the assets of CAI (M/R, March 1, p. 39). CAI president Fred T. Sonne told stockholders that another offer for the purchase of the firm's outstanding shares is forthcoming from another source. . . . *Hewlett-Packard Co., Palo Alto, Calif., has negotiated an agreement with F&M Scientific Corp. of Avondale, Pa., whereby F&M is to become a wholly owned subsidiary of H-P. Effective date is June 30. F&M makes gas chromatographs for the scientific analysis of various compounds.* . . . The Monsanto Co., St. Louis, Mo., has acquired a license to continue research and development work on a two-axis version of a solid-state display device invented by Electro-Tec Corp., Ormond Beach, Fla. Electro-Tec will retain exclusive rights to the one-axis applications of the device. The two-axis version is thought to offer a novel technique for flat screen visual display. . . . *The Perkin-Elmer Corp., Norwalk, Conn., scientific instrument manufacturer, has acquired Boller & Chivens, Inc., of South Pasadena, Calif., through an exchange of stock. B&C makes astronomical telescopes and specialized electro-mechanical devices. It will continue to operate under its present management and name as a unit of P-E's Electro-Optical Div.*

Missile/Space Stock Index

The Missile/Space Stock Index leveled off last week near the year's high point, with no special trend appearing. Most of the companies in the Index have now completed their audits, and made their financial figures available. These are listed below with comparable figures for 1963.



STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

1963-64 Performance of 19 Stocks Monitored in Missile/Space Stock Index

NAME OF COMPANY	'64 INCOME/SALES (IN MILLIONS)	'63 INCOME/SALES (IN MILLIONS)	'64 INCOME/SHARE	'63 INCOME/SHARE
AVCO CORP.	$22.6/$431.0	$22.4/$514.1	$2.05	$2.00
BENDIX CORP.*	$4.2/$468.0	$4.7/$565.0	$ .77	$ .87
BOEING CO.	$45.3/$1,969.5	$21.7/$1,771.4	$5.64	$2.71
DOUGLAS AIRCRAFT	$13.7/$650.1	$11.8/$698.3	$3.13	$2.69
GENERAL DYNAMICS	$42.6/$1,579.8	$32.7/$1,415.0	$3.77	$3.28
GENERAL PRECISION	$3.8/$219.4	$2.8/$217.9	$2.06	$1.42
GRUMMAN	$10.6/$599.2	$7.6/$468.3	$4.74	$3.40
LEAR SIEGLER†	$3.4/$96.7	$3.1/$97.8	$ .85	$ .77
LING-TEMCO-VOUGHT	$4.9/$322.8	$6.1/$329.0	$2.31	$2.12
LITTON INDUSTRIES*	$29.8/$686.1	$23.3/$553.1	$2.77	$2.23
LOCKHEED AIRCRAFT**	$32.2/$1,170.7	$32.6/$1,375.4	$2.99	$3.07
MARTIN MARIETTA	$37.2/$774.2	$34.6/$974.2	$1.67	$1.54
McDONNELL AIRCRAFT†	$14.9/$461.4	$10.8/$389.4	$1.84	$1.45
NORTH AMERICAN AVIATION (1st QUARTER FY '65)	$9.9/$473.7	$10.9/$486.1	$1.18	$1.30
LAST FULL FISCAL YEAR	$49.3/$2,189.6	$41.2/$1,868.7	$5.68	$4.91
NORTHROP†	$4.0/$159.8	$3.3/$144.0	$ .98	$ .78
RAYTHEON**	$6.4/$323.9	$4.9/$364.4	$1.50	$1.15
THIOKOL**	$3.0/$150.1	$4.8/$204.1	$ .56	$ .88
THOMPSON RAMO WOOLDRIDGE	$23.4/$553.4	$15.2/$482.6	$2.45	$1.98
UNITED AIRCRAFT	$29.1/$1,235.9	$21.5/$1,281.0	$4.23	$3.12

* Based on company fiscal year results.

** For first nine months of each year.

† First six months of new company fiscal year.

CLEAN

ROOMS

Special coatings are needed to help keep clean rooms—*clean!* Rust-Oleum research has developed unique coatings to meet the scrupulous needs of this *controlled environment area.* A skilled Rust-Oleum team of specialists and technical service personnel will be happy to work closely with you. May we hear from you?

RUST-OLEUM CORPORATION
2476 Oakton Street·Evanston, Illinois, U.S.A.
and
Rust-Oleum (Nederland) N.V.
Haarlem, The Netherlands

Over forty years of industry proof.

Distinctive as your own fingerprint.

RUST-OLEUM®

CLEAN ROOM SYSTEMS

contracts and procurements

AWARDS

AIR FORCE

$16,400,000—**Radio Corp. of America,** Defense Electronics Corp., New York City, for satellite tracking radar to be installed at Clear, Alaska, BMEWS site.

$7,700,000—**The Boeing Co.,** Seattle, for continued engineering on modernizing deployed *Minuteman* missiles.

$3,153,000—**Aerojet-General Corp.,** Sacramento, Calif., for continued research and development work on an engine for the *Tital III* rocket booster.

$2,999,997—**General Telephone & Electronics Corp.,** Sylvania Electric Products, Inc., New York City, for continued work on ground electronics equipment for *Minuteman* systems.

$1,700,000—**Electronic Specialty Co.,** Los Angeles, for design and construction of four 33-ft. telemetry-tracking stations for testing missiles and satellites.

$1,500,000—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for continued research on a space payload ejection mechanism.

$1,330,000—**North American Aviation, Inc.,** Anaheim, Calif., for maintenance and repairs of *Minuteman* guidance and control equipment.

$1,304,400—**North American Aviation, Inc.,** Columbus, Ohio, for production of unspecified missiles.

$1,186,650—**Garrett Corp.,** AiResearch Manufacturing Co., Phoenix, for gas turbine engines.

$1,031,958—**O.M.I. Corp. of America,** Detroit, for continued production of analytical photogrammetric plotter equipment.

$1,004,677—**Electronic Communications, Inc.,** St. Petersburg, Fla., for airborne communication equipment and engineering services.

$1,000,000—**General Electric Co.,** Philadelphia, for continued work on advanced re-entry vehicles.

$359,376—**TRW Space Technology Laboratories,** Redondo Beach, Calif., for octahedral research satellites.

$100,000—**Radio Corp. of America,** Missile & Surface Radar Div., Camden, N.J., for spares for AN/FPS-49 tracking radar test facility.

$59,286—**Thiokol Chemical Corp.,** Reaction Motors Div., Denville, N.J., for research in light emission caused by pressure fluctuations in rocket motors.

$39,988—**Cornell Aeronautical Laboratory,** Buffalo, N.Y., for analytical and experimental study of plasma surrounding re-entry bodies and resultant interaction with microwave radiation.

$38,525—**Aerospace Research Associates,** West Covina, Calif., for research on energy absorbing structures.

ARMY

$3,552,518—**General Dynamics Corp.,** Pomona, Calif., for *Mauler* missile feasibility study.

$3,200,000—**General Telephone & Electronics Corp.,** Sylvania Electric Products, Inc., New York City, for research and development in the electronic warfare field.

$2,172,777—**General Dynamics Corp.,** Pomona, Calif., for research and development on *Redeye* missile.

$1,350,000—**International Telephone & Telegraph Corp.,** New York City, for manufacture of two transportable electronic switchboards.

$600,000—**Philco Corp.,** Sierra Operations/Communications and Electronics Div., Menlo Park, Calif., to furnish five power amplifier terminals for military communciations.

NAVY

$79,634,615—**General Dynamics Corp.,** Pomona, Calif., for *Terrier* and *Tartar* missiles.

$21,900,000—**Ling-Temco-Vought, Inc.,** Aerospace Corp., Range Systems Div., Dallas, for modification of two existing range instrumentation ships to be used in the re-entry phase of the *Apollo* lunar mission.

$3,500,000—**Hughes Aircraft Co.,** Fullerton, Calif., for major components of the Navy's tactical data system.

$1,071,923—**Northrop Corp.,** Anaheim, Calif., fo checkout equipment for *Polaris* missiles.

$350,000—**Radiation Systems, Inc.,** Alexandria Va., for development of antenna feeds an tracking systems.

NASA

$1,260,000—**Quinn Construction Co.,** New Orleans for an addition to a central computer facilit at Slidell, La.

$1,087,645—**Pittsburgh-Des Moines Steel Co.** Pittsburgh, for construction of a spacecraft propulsion research facility at the Plum Brook Station, Sandusky, Ohio.

$827,750—**Martin Co.,** Baltimore Div., Baltimore to design, fabricate, test, check out, install an acceptance test one hydrodynamic support system for *Saturn V*.

$500,000—**Radio Corp. of America,** Missile & Surface Radar Div., Camden, N.J., for spares fo "C" band radars for project *Apollo*.

$457,580—**Spacelabs, Inc.,** Van Nuys Calif., fo development, design, fabrication and qualification of flight rated bio-instrumentation.

$408,217—**Spacelabs, Inc.,** Van Nuys, Calif., fo design, development, fabrication, test and delivery of bio-instrumentation system for *Apollo*

$200,000—**Computer Sciences Corp.,** Los Angeles for the development of an off-line data processing system for Project *Pioneer*.

$183,600—**Honeywell, Inc.,** California Ordnanc Div., West Covina, Calif., for design and development of albedo simulation system fo space environment simulation lab.

$183,300—**Dalto Electronics Corp.,** Norwood, N.J. for visual point light simulator.

$140,329—**H. B. Evans Co., Lynwood,** Calif., fo *Apollo* boilerplate.

$97,825—**General Dynamics Corp.,** Fort Wort Div., Fort Worth, Tex., for a manned spacecraft systems cost model study.

$97,597—**Avco Corp.,** Tulsa Div., Tulsa, Okla. for evaluation of thermal control coatings i space environments.

$90,000—**Perkin-Elmer Corp.,** Electro-Optical Div. Norwalk, Conn., for design and development o GSE for *Apollo* carbon dioxide sensors.

$85,576—**Grumman Aircraft Engineering Corp.** Bethpage, N.Y., for a study of *OAO* associated with a manned space station.

$28,642—**Bell Aerospace Corp.,** Aerosystems Div. Buffalo, N.Y., for *Apollo* service module, LEM and instrument unit structural analysis.

CBS Laboratories, Stamford, Conn., to suppl voice recorders for the *Gemini* progran (amount not disclosed).

INDUSTRY

$4,000,000—**Avco Corp.,** Lycoming Div., Stratford, Conn., from **Aerojet-General Corp.,** Sacramento, Calif., follow-on contract for the production of second-stage rocket motor case for *Minuteman*.

$3,000,000—**Motorola, Inc.,** Military Electronic Div., Scottsdale, Ariz., from **North America Aviation Inc.,** Space and Information System Div., Downey, Calif., to develop and manufacture a digital test command system for NASA' *Apollo* spacecraft.

$750,000—**H. C. Smith Construction Co.,** Compton, Calif., from **The Boeing Co.,** Seattle, fo general installation work on the first squadro of *Minuteman* Wing VI near Grand Fork AFB, North Dakota.

$325,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., from **Th Boeing Co.,** Seattle, increase in contract fo modification to existing equipment and spare for the *Minuteman* program.

$278,000—**Epsco, Inc.,** Westwood, Mass, from th **General Electric Co.,** Apollo Support Dept. Daytona Beach, Fla., for ground support equp ment for use in the *Saturn* program.

$67,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., from **Ele tro-Mechanical Research, Inc.,** Sarasota, Fla increase in contract for the *Gemini* magneti tape recorder system.

System Development Corp., Santa Monica, Calif from the **State of California,** to advise the stat during its search for ways to apply aerospac engineering techniques to state problem (amount not disclosed).

Circle No. 4 on Subscriber Service Card

ATOMIC ENERGY COMMISSION

$2,895,380—**University of Rochester,** Rochester, N.Y., for a five-year contract supporting the university's Atomic Energy Project, a study on the biological effects of radiation.

American Machine & Foundry Co., New York city, for an improved system for concentration and disposal of radioactive wastes from nuclear power plants to be designed, tested and installed at the Air Force's PM-1 nuclear power plant near Sundance, Wyoming (amount not disclosed).

ADVANCED RESEARCH PROJECTS AGENCY

$1,300,000—**General Applied Science Laboratories, Inc.,** Westbury, N.Y., for research in aerospace physics problems.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

General Research Procurement Branch
2101 Webster-Seabrook Road
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas 77058

Negotiations will be conducted with North American Aviation, Inc., for and engineering study on program definition, mapping and survey system for *Apollo* spacecraft interface definition. For information only; RFP not available.

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

GSFC will negotiate with Superior Engineering Co. for a continuation of field launch support for the rocket grenade payload program. For information only; RFP not available.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Virginia

Langley Research Center is negotiating a conract with Perkin-Elmer Corp. for investigative studies relating to the feasibility of obtaining diffraction limited optics for space applications. For nformation only; RFP not available.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Virginia

Negotiations will be conducted with Aero Chem Research Laboratories, Inc., to perform a study of chemical release in the upper atmosphere. For information only; RFP not available.

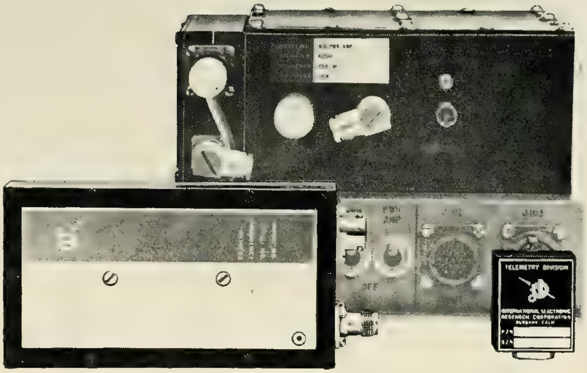
Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Virginia

Langley Research Center is negotiating a conract with the Electronics and Space Division of Emerson Electric Co., for studies of a digital adaptive control system. For information only; RFP not available.

Air Force Flight Test Center
Directorate of Procurement (FTMKR-1)
Edwards Air Force Base, California 93523

Negotiations are being conducted with TRW/Space Technology Laboratories for additional contact experiments in space. This notice does not solicit additional proposals, but is issued for the benefit of prospective subcontractors.

In proven
Aerospace Systems



IERC telemetry equipment
keeps fast company

Many operational aerospace systems employ IERC telemetry components or subsystems. IERC has been acclaimed as providing superior telemetry equipment. This is proven in shot after shot and flight after flight without equipment failure. IERC's line of solid state telemetry equipment, together with the "know how" that produced it, can be put to work on your total requirements. An inquiry will produce fast response. Write today.

Compare our "full range" telemetry background.

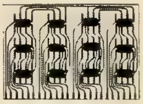
IERC TELEMETERING* APPLICATIONS** ***	TRANSMITTERS	VCOs	MIXER AMPLIFIERS	POWER SUPPLIES	SIGNAL CONDITIONERS	TOTAL SYSTEMS	TEST EQUIPMENT
AIRCRAFT	●	●	●	●	●	●	
AIRBORNE MISSILES	●	●	●	●	●	●	●
SPACECRAFT	●						●
SPACE PROBES	●						
BALLISTIC MISSILES		●	●	●		●	●
DRONES	●	●	●	●	●	●	●
A.E.C.		●					●

*ALL SOLID STATE **CUSTOMERS ON REQUEST
***GROUND BASED EQUIPMENT HAS ALSO BEEN SUPPLIED BY IERC

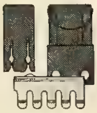
IERC

INTERNATIONAL ELECTRONIC RESEARCH CORPORATION
135 W. Magnolia, Burbank, California 91502 A DCA subsidiary Dept. MR-31565

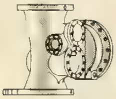
more
problem
solvers
from
IERC



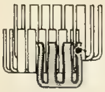
WELDED
MICRO-CIRCUIT
PACKAGING



HEAT-DISSIPATING
TUBE SHIELDS

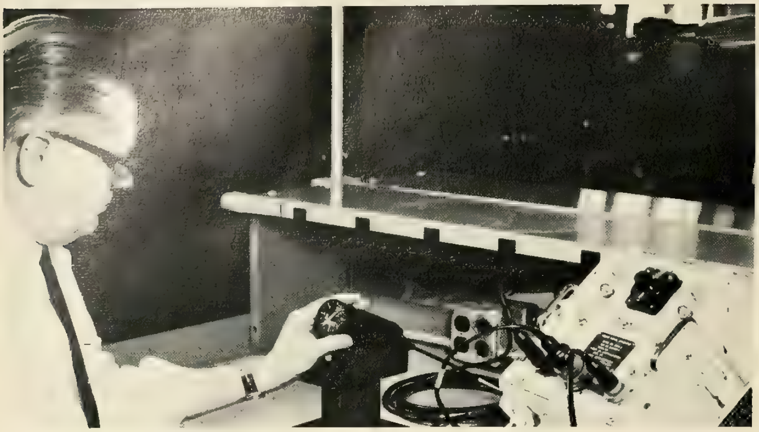


MILLRICH
SPACE-AGE
MACHINING



TRANSISTOR
HEAT
DISSIPATORS

Circle No. 7 on Subscriber Service Card



New Product of the Week: Torque Signal Simulator

A torque signal simulator, designed to simulate signals generated by electromagnetic torque tube sensors that produce two modified sinusoidal signals with a phase relationship proportional to the developed torque, is being marketed by The Liquidometer Corp.

The instrument produces output signals to which torquemeters under test respond exactly as they do to the actual sensors. Designed to operate from a 60- or 400-cps power source, the unit generates two sinusoidal output signals. One is fixed-phase reference signal; the other is a torque signal controlled by the operator to establish a specific phase relationship between the two signals by use of a vernier dial.

The operator can shift torque output through all values from zero to 360 degrees in relation to the reference signal. The unit meets MIL-T-21200D environmental specifications.

Circle No. 151 on Subscriber Service Card

Display Oscilloscope

A MS Series display oscilloscope, originally designed for PAM bar chart display with all IRIG formats, is available for multichannel analog display from Applied Development Corp.

The K-7855 system combines a 30-channel analog multiplexer with an MS-3 scope, 17-in. screen, or an MS-4 scope with a 14-in. screen for bar chart type display up to 30 measurements in parallel.

The system can be expanded to 100 channel display capacity per scope. Individual channel intensification, alternate X-Y- or Y-time display, zero and full scale reference are available options.

Circle No. 152 on Subscriber Service Card

Reversing Counter

A general-purpose reversing counter with a frequency range of 2 cps to 250 kc is being marketed by Atec, Inc.

The Model 5ASO6 features an anticoincident circuit which allows input signals to be fed into both A and B channels without regard to phase. This means that signals may be added in A channel and subtracted at B channel simultaneously, the firm pointed out. With the optional BCD, the instrument may be used in conjunction with digital printers or as a digital servo.

Specifications include an impedance of 1 megohm and sensitivity of 100 mv RMS for forward, reverse and bidirectional operation. Operating temperature is —20° to 60°C. Input power is 115v ± 10% or 220v ± 10%, 50 to 60 cps at 50 watts.

Circle No. 153 on Subscriber Service Card

Cadmium Plating

An electrolyte, especially designed to prevent hydrogen embrittlement when plating on ultra-high-strength steels, has been developed by Selectrons, Ltd.

The cadmium LHE solution permits fast deposits on specialty steels having tensile strengths of 260,000 psi and more, the firm says. Deposits fill requirements of specification QQ-P-416a without needing subsequent baking for embrittlement relief.

Using a brush-on apparatus, the solution is deposited in only those areas where it is actually needed. No disassembly is required. Extensive masking or stopping off is avoided and, because plating tanks are eliminated, only small quantities of electrolyte are needed.

In operation, the cathode lead from the Selectron power pack is connected to the object to be plated and the other lead fitted with a special stylus-anode which is wrapped in cotton and saturated with electrolyte. Thickness of deposit is controllable within 0.0001 in. by means of a totaling ampere-hour meter, whose readings are readily converted into thicknesses.

Circle No. 154 on Subscriber Service Card

Photomultiplier Modules

Information International, Inc., has available an integrated set of modules for photomultiplier applications where temperature stability, reliability, sensitivity and dynamic range are major considerations.

The set includes: photomultiplier preamplifier; dual log amplifier; dual ac coupled emitter follower; gated operational intergrator with operational inverter; two-state difference detector and dual two-state difference detector. A three-state difference detector employs a Darlington connected, differential preamplifier. Three logic level outputs correspond to less than, equal to or greater than comparisons of the input signals.

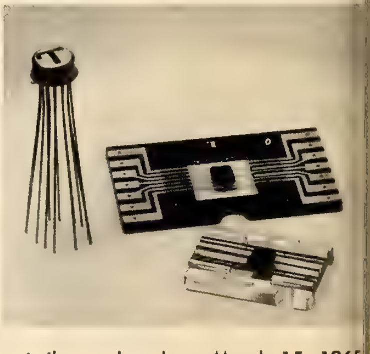
The modules incorporate networks which monitor average photomultiplier anode current and signal clipping. Appropriate output signals result when thresholds are exceeded.

Circle No. 155 on Subscriber Service Card

JK Flip-Flop

Transitron Electronic Corp. has developed a single-phase, dc-coupled flip-flop, capable of operating at 20 mc in the counting mode.

The device is a general-purpose JK flip-flop with the basic circuit design of the HLTTL family. The unit has a noise rejection of 600 mv, fanout of 20



and capacitive line driving capability of 300 pf. An inverting buffer has been incorporated in the element for use as a clock line buffer. Units are available in TO-5 and flat packs.

Circle No. 156 on Subscriber Service Card

Laser Coatings

A line of laser coatings for a number of solid-state materials has been developed by Spectrum Systems, Inc.

The coatings are designed to withstand a wide range of temperature extremes and have been used with ruby, yttrium aluminum garnet, calcium fluoride with samarium or uranium, quartz, glass and sapphire. Percentage of reflectivity is controlled from 0.5 to 99.6%; wavelength is controlled from 3,900 Angstroms to 15 microns.

Circle No. 157 on Subscriber Service Card

Microminiature Delay Lines

General Instrument Corp's Radio Receptor Div. is marketing a series of microminiature delay lines with associated read-write amplifier circuits in microelectronic form and built into the delay line package itself.

Designated the MMDL series, the units measures 2 in. in diameter, 0.5 in. high, including a 7-pin connector, and weigh less than 1.5 oz. They are available in delay ranges of 10 to 500 microsecs. and are longitudinal in type. Under tests, the devices operate dynamically at shocks of over 100 g's and in vibration as high as 20 g's in each of three planes. Temperature coefficients of delay are 20 parts per million per degree C.

Circle No. 158 on Subscriber Service Card

Mass Spectrometer

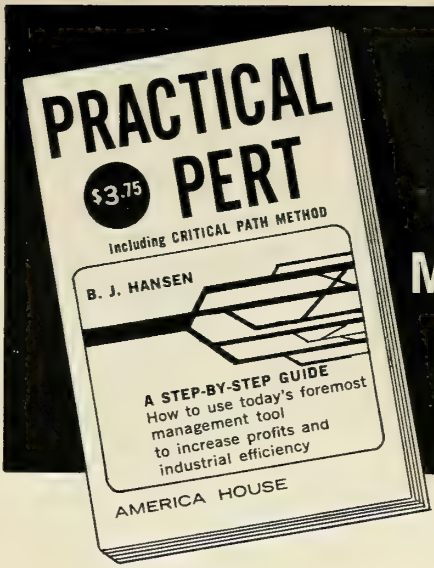
The Model RGA omegatron mass spectrometer, designed for partial pressure analysis of gases, is being marketed by Sloan Instruments Corp.

The unit ionizes the gas mixture under consideration and separates the constituent ions according to their mass. Features include a full-scale deflection at 10^{-9} torr; minimum detectable partial pressure of 3×10^{-10} torr; a mass range of 2 to 50 and automatic sweep of the entire range. The sensing tubes' internal elements may be RF heated to 900°C, and the hard glass envelope may be baked to more than 450°C.

Circle No. 159 on Subscriber Service Card

Signal Conditioning System

An all-solid-state dc amplifier/bridge excitation unit for use with strain gages, resistance thermometers and other low-level bridge-type transducers is available


PRACTICAL PERT
$3.75
Including CRITICAL PATH METHOD
B. J. HANSEN
A STEP-BY-STEP GUIDE
How to use today's foremost management tool to increase profits and industrial efficiency
AMERICA HOUSE

FOR ALL LEVELS OF MANAGEMENT

2nd Big Printing!

$3.75

by B. J. HANSEN

(member of the original Polaris-PERT Team)

You get the complete **PERT** system and, for the first time, a **PERT** technique showing you how to predict and monitor profit on a continuing bi-weekly cycle.

Chapter XII, "Profit **PERT** and Incentives," brings you the Martin Company case history showing how the Titan III **PERT**-profit system works: In the words of Secretary of Defense Robert McNamara, "(Titan III) is probably the best managed contract we have, and it is the best managed almost entirely because of the tremendous incentive given to that contractor in the form of potential profit increases to hold his costs down."

PRACTICAL PERT tells how and when to meet contract obligations, how to keep programs on schedule, how to win highest incentive fees. **PERT**, developed for the nation's defense programs, can be applied to management operations to monitor profit as well as cost, time and performance in the fields of construction, chemical processing, manufacturing . . . and wherever complex systems are involved.

PRACTICAL PERT contents

I INTRODUCTION TO PERT
II THE ABC'S OF PERT
III PERT & TIME
IV HOW PERT PLANS
V HOW PERT CONTROLS
VI BUILDING PERT
VII WHAT IS NETWORKING
VIII REFINING THE NETWORK
IX MEASURING MANAGEMENT RISK
X PERT & COST
XI PERT COSTS & COMPUTERS
XII PROFIT PERT & INCENTIVES
XIII PERT DATA DISPLAY

AMERICA HOUSE
Dept. A
1001 Vermont Avenue, N.W., Washington, D.C. 20005

Send Me ☐ Copies of Practical Pert $3.75
.25c Handling
$4.00

☐ Check Enclosed ☐ Bill Me

Name .... Job/Title ....

Address .... City .... ☐ HOME? ☐ BUSINESS?

Zip Code .... State .... Co. Name ....

from American Wiancko Instrumentation Div. of Tamar Electronics, Inc.

The Type 11-1007 simultaneously supplies a precision, isolated 5-v dc bridge excitation voltage from an unregulated 28-v dc source, and differentially amplifies the bridge transducer output. The device provides three selectable gain ranges—50 to 150, 140 to 500 and 400 to 1,000—with a resolution of ±15 mv and gain stability better than ±0.5% for supply voltage variations between 22 and 34v dc. Performance is stable to temperatures between −65°F and 250° F and under 35 g's acceleration from 50 to 2,000 cps. It meets MIL-I-26600 specifications.

Circle No. 160 on Subscriber Service Card

Heat Flux System

The Model 1010 anemometer, designed for high-frequency measurements in both gases and liquids, is being marketed by Thermo-Systems, Inc.

The device features a quartz-coated hot film sensor, a thin-film of platinum on a glass backing. The quartz coating is sputtered on in a thin layer to isolate the platinum, making it ultra-stable in both gases and liquids, the firm explained. Another feature is a solid-state floating bridge amplifier, providing low electronic drift.

The unit has 30-watt power and a frequency response from 0 to 50,000 cps. Sensitivity of a zero suppression circuit is accurate to 0.1%. The output filter has five high pass bands—10, 30, 100, 300 and 1,000 cps—and five low pass filters—1, 3, 10, 30 and 100 kc. Output noise level is less than 0.4 mv RMS.

Circle No. 161 on Subscriber Service Card

Materials Analyzer

Numec Instruments and Controls Corp. is marketing an instrument designed to reduce analysis time required for surface area analyses of powdered and porous materials while retaining accuracy and precision.

The Model AFA 4 apparatus uses either the classical B.E.T. method or an adsorption flow technique. It employs a single gas—nitrogen—for development and quality control applications, eliminating the inconvenience of mixed gases in surface area determinations, the firm says. Material density measurements require only a single displacing gas—nitrogen for normal materials, helium for surface active materials. Desorption isotherms may be obtained for pore volume determinations.

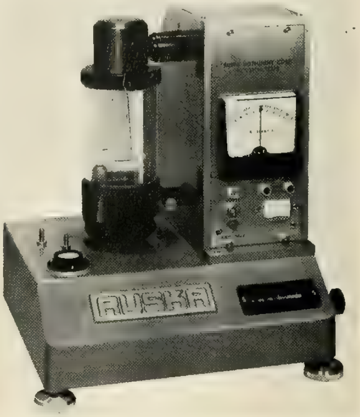
The unit provides a single point check in 10 min. with a reproducibility of ±5% or better. Range is from 0.2 to 1,000 sq. m/g.

Circle No. 162 on Subscriber Service Card

Pressure Standard

Ruska Instrument Corp. is marketing a quartz electro-null pressure standard, designed to calibrate pressure-sensitive devices to an accuracy of 0.01% of reading plus 0.005% full scale.

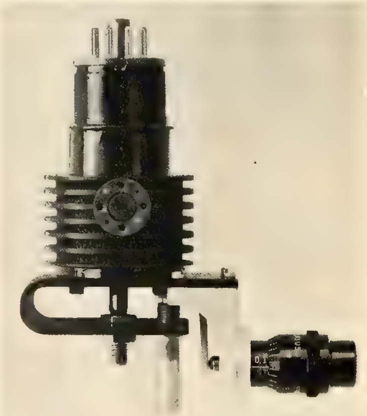
The device combines a fused quartz Bourdon tube with an electronic system and precision gear train to provide digital data display on a mechanical counter. It can be used for gauge or absolute measurements in ranges from 0 to 100 psi. Input is 115v ac, 60 cps. The unit measures 12x11x13.5 in. and weighs 30 lbs.



Circle No. 163 on Subscriber Service Card

Millimeter Klystron

Beam Tube Corp. is marketing a millimeter reflex klystron with a tuning range of 46 to 54 gc. The Model 50BT/A has a minimum power of 200 milliwatts and peak power of over 600 milliwatts. Optimum loading will usually double the minimum output and will substantially increase power throughout the band, the firm says. The unit is warranted for 500 hours.



Circle No. 164 on Subscriber Service Card

Charge Amplifier

A group of charge amplifiers, the 9000 Series, has been announced by Columbia Research Laboratories, Inc. The units are capable of transmitting shock and vibration data from piezoelectric accelerometers over cable lengths of up to 1 mi. (100,000 pf) without appreciable loss of gain or frequency response, the firm says.

The units are available in 1-, 2-, 3- and 6-channel models and feature a built-in potentiometer control expressed in picocoulombs. Gain is adjustable to ±5v peak full scale output with transducer sensitivity range from 1.0 to 100 picocoulombs per g. Noise is less than 1% of full scale output; instantaneous recovery with overloads up to 20 time full scale is standard.

Circle No. 165 on Subscriber Service Card

Leak Sealant

Space Environment Laboratories, Inc., is marketing a high-vacuum leak sealant—a silicone resin with a low vapor pressure. The sealant is packaged in aerosol containers, making it possible to reach areas of limited access.

The product will repair leaks as large as 2 micron liters per second with the system under evacuation, thus eliminating expensive down time. It can be used to repair larger leaks if the system is broken to atmosphere.

The vapor pressure of the sealant is highest when initially sprayed on the system. Pressure can be reduced to nearly that of most metals by curing with heat. Recommended cure times are 30 minutes to 200°C and 15 minutes at 250°C. Curing can be effected at room temperature over a period of several days. The sealant can be removed with any acetate, ketone or ester solvent.

Circle No. 166 on Subscriber Service Card

I-C Decade Counter

An integrated-circuit decade counter, using a hybrid combination of integrated circuits, transistors and silicon-controlled rectifiers, is being marketed by Robotomics Research Facility of Allegany Instrument Co.

The Model BCD8 can be used for three functions: a 3-mc counter; an 8-line BCD-to-decimal display; or a 1-megacycle shift register. To go from one operational mode to another, only the connector wiring has to be changed.

The unit features wide-angle viewing and is 7-segment, in-plane with 100,000-hour bright lamps. Supply requirements are 12v, 260 ma, for logic circuit and 5v, 60 cycles, for lamp display. Temperature range is 0 to 65°C.

Circle No. 167 on Subscriber Service Card

WHO...WHAT...WHERE...

in the Missile/Space Industries!

SECTION B-2
COMPONENT MISSILE/SPACE MANUFACTURERS
SECTION B-1
MAJOR MISSILE/SPACE MANUFACTURERS
SECTION D
ILE/SPACE CONSULTANTS & SPECIAL SERVICES
EXECUTIVE BRANCH
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
FRANCE
Missile/Space Manufacturers
WORLD SPACE DIRECTORY

Spring 1965 Edition

17,000 KEY PERSONNEL IN 4,250 COMPANIES
NAMES—ADDRESSES—PRODUCTS—SERVICES
—MISSILE/SPACE REFERENCE MATERIAL—

No matter what you're looking for in missile/space, you'll find your first lead in the WORLD SPACE DIRECTORY. Whether you're interested in reaching key industry or defense executives, bidding on a government contract, planning research or production programs, sizing up competition, or looking for a job . . . the WORLD SPACE DIRECTORY is your primary source of information.

RETURN THIS COUPON

WORLD SPACE DIRECTORY
New Edition
Spring 1965
50% Revised

$12.50 per copy—U.S., Possessions, Canada; $13.50 all other countries

☐ Copies ☐ Bill me ☐ Bill Company

Name

Title/Position

Street **City** **State** **Zip #**

Company Name

Division

1001 Vermont Avenue, N.W., Washington, D.C. 20005

let us move with you!

Six Weeks Is Required To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, if possible, the address label from your last issue . . . include your postal ZIP number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

◆◆◆

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

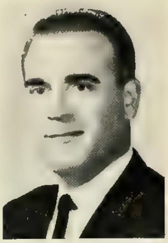
Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Paris, France—11 Rue Condorcet; TRU 15-39

names in the news

BAKER


ROBERTS

TAYLOR

CARLTON

Orville R. Baker: Elected vice president-engineering of Signetics Corporation, along with F. Sydney Lodge, who was elected vice president-controller and treasurer. Signets, manufacturer of semiconductor integrated circuits, is a subsidiary of Corning Glass Works.

John A. Roberts: Elected president of Magnetic Core Corp. Formerly director of marketing and vice president at Magnetic, he has had 25 years experience in the electronics and powdered iron core industries.

Dr. Theodore B. Taylor: Named one of the recipients of this year's Ernest Orlando Lawrence Memorial Award for meritorious contributions to the field of atomic energy. He is deputy director, scientific, of the Defense Atomic Support Agency. The award, which will be presented on April 29 at the National Academy of Sciences in Washington, consists of a medal, a citation and $5,000. In addition to Dr. Taylor, four other scientists were awarded the prize: **Dr. George A. Cowan,** Los Alamos Scientific Laboratory; **Floyd L. Culler,** Oak Ridge National Laboratory; **Milton C. Edlund,** Babcock & Wilcox Company; and **Dr. Arthur C. Upton,** Oak Ridge National Observatory.

A. George Carlton: Named to head a new space communications program at the Applied Physics Laboratory of The Johns Hopkins University. The study concerns a ground support network for space flight communication in the *Gemini* and *Apollo* programs.

Robert J. Schlesinger: Elected vice president of marketing and product development of International Telephone and Telegraph Corporation's Data and Information Systems Division. He was formerly with ITT Federal Laboratories where he was responsible for building a tactical warfare systems laboratory and directing special-purpose digital communications work. **Dr. Harold Tornheim** was appointed as a scientist in the systems research center at ITT Federal Laboratories, where he will be involved in surveillance and microwave systems studies.

Theodore S. Smitke: Appointed senior vice president of Bart Manufacturing Corporation, electroforming, plating and microwave equipment specialists. He will be responsible for plant supervision, research and development, and production management.

Larue D. Rexroat: Appointed vice president and general manager of the American Wiancko Instrumentation Div. of Tamar Electronics, Inc., research, development and manufacturing of dynamic measurement and control products division of Tamar.

Cecil Stearns: Became vice president and director of engineering at Tec Seal Corp. manufacturer of Teflon, Tec-Rings and other sealing products. He will coordinate manufacturing, be responsible for quality control and perform design engineering functions.

Gerard Q. Decker: Elected corporate vice president of Zero Manufacturing Company. He was formerly with Litton Industries and has 25 years experience in industrial and military engineering and marketing.

Milton Lewis: Elected president and general manager of the Ralph M. Parsons Company, an engineering-construction firm

M. C. Hegdal: Named vice president of 3M Company's Magnetic Products Div He was formerly division general manager

J. W. Keener: Named to the Balance of Payments Advisory Committee, which will advise Secretary of Commerce **John T Connor** on the U.S. balance of payments program of restricting overseas investments. He is president of The B. F. Goodrich Company.

Ling-Temco-Vought, Inc., has recently named five vice presidents for its newly founded subsidiary, LTV Aerospace Corporation. The following persons were named to new posts: **J. R. Clark,** vice president and general manager, Vought Aeronautics Div.; **W. R. Kiefer,** vice president and general manager, Michigan Division; **A. H. Perry,** president of Kentron Hawaii, Ltd., Honolulu; **Dr. G. M. Monroe,** general manager, Astronautics Division; **J. W. McGuyrt,** general manager Range Systems Division.

Dr. Alfred E. Brown: Named to the board of directors of Washington Technological Associates, Inc. He is president of Harris Research Laboratories, Inc., and was first chairman of the Science Bureau of the Metropolitan Board of Trade in Washington.

—when and where

MARCH

International Symposium of the Solar Energy Society, Phoenix, March 15-17.

Los Angeles Chamber of Commerce Aerospace Committee Meeting, Los Angeles, March 16.

Conference on Aerospace Engineering and the Ninth Minta Martin Lecture, sponsored by the University of Maryland AIAA (National Capital Section), Center of Adult Education, UM, College Park, Md., March 16.

Advanced Planning Briefings for Industry, sponsored by the Department of Defense and National Security Industrial Assn., Americana Hotel, New York City, March 16-17.

Aviation and Space Conference, sponsored by the American Society of Mechanical Engineers, Statler-Hilton Hotel, Los Angeles, March 16-18.

Third National Inter-Service Data Exchange Program (IDEP) Conference, sponsored by the IDEP Contractor Advisory Board, in conjunction with the Army, Navy and Air Force, Albuquerque, N.M., March 16-18.

Spring Conference of the Electronic Industries Assn., Mayflower Hotel, Washington, D.C., March 16-19.

Second Annual Southeastern Symposium on Government Contracts, sponsored by The National Contract Management Assn., Ramada Inn, Cocoa Beach, Fla., March 18-19.

Third Goddard Memorial Symposium of the American Astronautical Society, Marriott Key Bridge Hotel, Washington, D.C., March 18-19.

International Convention of the IEEE, New York Hilton Hotel and New York Coliseum, New York City, March 22-25.

1965 Microwave Measurement Symposium, sponsored by Weinschel Engineering Co., Sherry Netherland Hotel, New York City, March 22-25.

Spring National Convention of the Society for Nondestructive Testing, Los Angeles, March 22-26.

22nd Annual Conference of the Western Section of the Society of the Plastics Industry, Hotel del Coronado, Calif., March 24-26.

Convention of the American Society of Photogrammetry and the American Congress on Surveying and Mapping, Shoreham Hotel, Washington, D.C., March 28-April 3.

Spacecraft Magnetics Workshop, sponsored by the National Aeronautics and Space Administration, Jet Propulsion Laboratory, Pasadena, Calif., March 30-April 1.

Seminar on Random Vibration, sponsored by MB Electronics, MB facility, New Haven, Conn., March 30-April 8.

Advanced Planning Briefings for Industry, sponsored by the DOD and NSIA, Conrad Hilton Hotel, Chicago, March 31-April 1.

Optical Society Meeting, Statler Hilton Hotel, Dallas, March 31-April 2.

APRIL

IEEE Seminar on Space Vehicle Reliability, Airport Marina Hotel, Los Angeles, April 2.

Sixth Structures and Material Conference, sponsored by the AIAA, Riviera Hotel, Palm Springs, Calif., April 5-7.

International Symposium on Fission Product Release and Transport Under Accident Conditions, sponsored by the Oak Ridge National Laboratory, Oak Ridge, Tenn., April 5-7.

Symposium on Advanced Propellant Chemistry, sponsored by AIAA and ACS, Detroit, April 5-7.

Symposium on High Energy Physics, sponsored by the Institute of Physics and the Physical Society (England), Birmingham, Eng., April 5-8.

International Symposium on Techniques of Memories, sponsored by the French Society of Electronics Technicians and Radioelectricians, Paris, April 5-10.

International Nuclear Exhibition and Conference, sponsored by the Institution of Nuclear Engineers, Brighton, Eng., April 5-10.

Third Navy Microelectronics Program Conference, U.S. Naval Postgraduate School, Monterey, Calif., April 6-7.

1965 Annual Region III Meeting of IEEE, Robert E. Lee Hotel, Winston-Salem, N.C., April 6-8.

IEEE Computer Technology Conference, Thunderbird Hotel, Los Angeles, April 6-8.

Dynamics of Defense Marketing, sponsored by the National Defense Education Institute, Washington, D.C., April 6-8.

Anniversary Meeting of the Chemical Society, Glasgow, Scotland, April 7-9.

1965 International Exhibition of Electronic Components and First International Exhibition of Audio Equipment, Paris, April 8-13.

23rd Annual Meeting of the National AeroSpace Services Assn., Washington Hilton, Washington, D.C., April 12-13.

Practical Aspects of Dynamic Programming, sponsored by the Detroit Research Co., Detroit, April 12-13.

Conference on Atomic Spectra and Radiation, Oxford, Eng., April 12-14.

1965 Annual Region VI Conference of the IEEE, Las Vegas, April 13-16.

15th Annual National Telemetering Conference, sponsored by the IEEE, ISA and AIAA, Shamrock-Hilton Hotel, Houston, April 13-15.

Advanced Planning Briefings for Industry, sponsored by DOD and NSIA, Marriott Motor Hotel, Dallas, April 14-15.

1965 Electronics & Instrumentation Conference and Exhibit, sponsored by ISA, Cincinnati Gardens, Cincinnati, Ohio, April 14-15.

Advertisers' Index

AMERICAN TELEPHONE & TELEGRAPH CO. 2
Agency—N. W. Ayer & Son, Inc.

AMPEX CORP. 32
Agency—Cunningham & Walsh, Inc.

BECKMAN INSTRUMENTS, INC. 9
Agency—Erwin Wasey, Ruthrauff & Ryan, Inc.

CRYOVAC, INC. 35
Agency—The Jay H. Maish Co.

HUGHES AIRCRAFT CO. 47
Agency—Foote, Cone & Belding

HYDRO-AIRE, DIV. OF CRANE CO. 11
Agency—Scott, Rifkin & Wilson, Inc.

INTERNATIONAL ELECTRONIC RESEARCH CORP. 39
Agency—The Martin R. Klitten Co., Inc.

LOCKHEED MISSILES & SPACE Co. 4, 5
Agency—Hal Stebbins, Inc.

McDONNELL AIRCRAFT CORP. 36
Agency—John Patrick Starrs, Inc.

NORTHROP CORP. 24, 25
Agency—Doyle, Dane, Bernbach, Inc.

REEVES SOUNDCRAFT CORP. 10
Agency—The Wexton Co., Inc.

ROCKET RESEARCH CORP. 48
Agency—Gorin & Holmes, Inc.

ROHR CORP. 6
Agency—Lane & Huff

RUST-OLEUM CORP. 38
Agency—D'Arcy Advertising Co.

Two on the Aisle

AFTER A ROADSHOW TRYOUT in Los Angeles, the Department of Defense Advanced Planning Briefings move this week to New York. The California opening, to put it bluntly, was a flop.

The cast was excellent, but the lines were terrible. Backers of the show, DOD and the National Security Industrial Assn., now are engaged in tightening and re-writing the presentation in an effort to gain a more favorable reception from New York critics.

The theatrical analogy is not far off—for the briefings may best be characterized as a dramatization of Secretary of Defense McNamara's posture statement to Congress. And while we enjoyed the book, the stage version added almost nothing worthwhile.

We realize this is a harsh evaluation of a very sincere effort by DOD and NSIA to bring worthwhile defense planning information to a broad segment of industry. Perhaps we expected too much. But if we did, so did those industry members attending. The fault may have been as much in raising such high hopes as in the failure to fulfill them.

The problem also lies, in part, in the fact that the ground rules for the briefings make it almost impossible to do the job many hoped they would do. Assistant Secretary of Defense Paul R. Ignatius faced forthrightly up to this in his keynote remarks on the opening day:

"A number of problems, however, had to be resolved before we could undertake a series of industry briefings. First, there was the problem of security. The basic ground rule is that classified information can be furnished only on a 'need to know' basis. Obviously, different groups of Defense contractors have differing requirements for information. Second was the problem of equity. We wanted to be sure that all current and potential contractors were given equal access to the data they 'need to know.' And third was the problem of possible misunderstanding about the firmness of our detailed plans for the future. The Five-Year Force Structure and Financial Program is, in fact, subject to constant change. In those areas involving established weapon systems with long lead times, the projections are relatively firm, but in other areas, particularly research and development, even programs in the Five-Year Force Structure are necessarily both highly tentative and incomplete.

"The first two problems were resolved by dividing the briefings into two types—unclassified briefings, of which this present conference is the first, and classified briefings, which are conducted by the individual military services. I hope to avoid the third problem by specifically cautioning all participants in this conference that the programs we will be discussing in this meeting and in the classified sessions are very much subject to change. Accordingly, this information must be used with care, and it will be up to each of you to keep up to date, through your usual channels, with changes in programs of specific interest to your firm."

Industry's willingness to accept this third proviso of uncertainty in exchange for valuable hints of DOD future planning was expressly stated by the industry keynoter, President Thomas V. Jones of Northrop.

But it was on the first two problems that the briefings stumbled.

The de-classification task was tackled with such strict severity that it castrated the presentations. Left with little of value to say, the military services fell back on broad-based briefings about organizations and cost effectiveness.

As one company president put it, "If DOD is interested in cost reduction and cost effectiveness, it would not have held the briefings. Anyone who doesn't already know the organizational charts of the services should get out of the business."

That leads directly to the second problem. In aiming much of the briefing at the little fellow to satisfy the question of equity, the planners left large groups from the big primes with nothing of value to take home. Some of the industry's larger companies sent from 25 to 50 planning, marketing and contract personnel to the two-day session. We doubt if they will repeat this mistake in New York, Chicago, Dallas or Washington.

There also were some unnecessary physical difficulties. Watching attendees laboriously attempting to take notes in a darkened hall while Navy officials plowed through a sea of unnecessary slide presentations made one wonder whether the planners had given much thought to some of the practical aspects of the sessions.

There was general agreement that the Army briefing, while too long, was the most informative. The Air Force was second best and the Navy ran a poor third. We believe that shortening the presentations by elimination of material which is common knowledge to anyone in the industry would improve them. But there must be some substitution or the briefings will nearly disappear. More emphasis on service needs in areas where specific industry help is sought would be of value.

WE DO NOT FEEL, HOWEVER, that the entire blame—if one is to assess blame for a valiant effort to do something worthwhile against almost insurmountable odds—that the entire blame for the failure of the briefings rests with the sponsors. The scheduled question-and-answer sessions provide valuable and unusual access to top-level DOD personnel. Yet industry representatives came woefully lacking in worthwhile questions. Most questions were not very piercing and many indicated that the questioner was sadly lacking in fundamental knowledge contained in industry trade journals and basic source material. It also appeared that the requirement for written questions was discouraged, since it was impossible to follow up a line of questioning if the initial answer were unsatisfactory.

NSIA and DOD looked candidly at these problems in a post-briefing critique and are now attempting to polish the presentations somewhat. Under the rules, however, there is little hope that the changes will be substantial, even with a slightly different cast.

The show, never a smash hit, will remain only a pleasant little review.

William J. Coughlin

Systems Analysts & Preliminary Design Engineers for Advanced Space Guidance & Control Systems

Rapid expansion of space contracts, projects and studies at the HUGHES Aerospace Divisions in Southern California has created unusual opportunites for several qualified Engineers, Physicists and Mathematicians for Advanced Space Systems assignments.

Space-mission openings are available in the following areas:

- **INTERPLANETARY GUIDANCE & NAVIGATION**
- **TRANS-LUNAR GUIDANCE & NAVIGATION**
- **EARTHORBITNAVIGATION**
- **RENDEZVOUS & RE-ENTRY GUIDANCE**

Current requirements include:

Guidance & Navigation System Synthesis

To study and develop guidance and navigation equations and techniques; make feasibility and error analyses; establish subsystem and component requirements; conduct system preliminary design; plan inertial, optical and electro-magnetic instrumentation.

Control System Synthesis

To analyze control system requirements for various space vehicles; establish subsystem and component requirements; conduct system preliminary design; study measurement instrumentation and torque-producing equipment.

Simulation

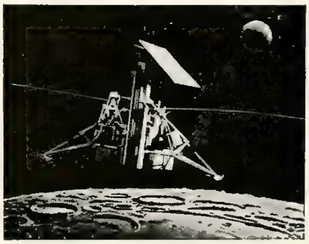
To plan digital simulation for studies related to earth orbital, trans-lunar, interplanetary and reentry trajectories; analog simulation of rendezvous guidance and control systems.

Applied Mathematics

Space mathematics applications related to orbit determination, trajectory analysis, optimization procedures, perturbation theory and space mechanics.

If you hold an accredited Engineering, Physics or Mathematics degree, are a U. S. citizen and feel that you are qualified by interest and experience in one or more of these areas, please airmail your resume to:

MR. ROBERT A. MARTIN
Head of Employment
HUGHES Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 34, California



WE PROMISE YOU A REPLY WITHIN ONE WEEK.
An equal opportunity employer.

Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS

ADVANCE REPORT / ROCKET RESEARCH

HYDRAZINE MONOPROPELLANT ROCKETS READY FOR FLIGHT

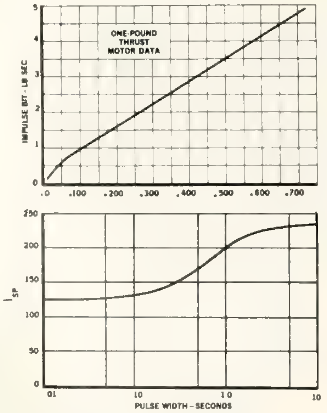
SYSTEM USING SHELL CATALYST PIONEERED BY ROCKET RESEARCH CORP.

A vast potential for space craft reaction control capability has been opened up as a result of new developments at Rocket Research. Conclusive demonstrations by RRC indicate the revolutionary Shell 405 catalyst represents a major breakthrough in hydrazine monopropellant systems. Liquid hydrazine systems now have much broader application, promise superior performance, easier handling, cheaper propulsion than ever before.

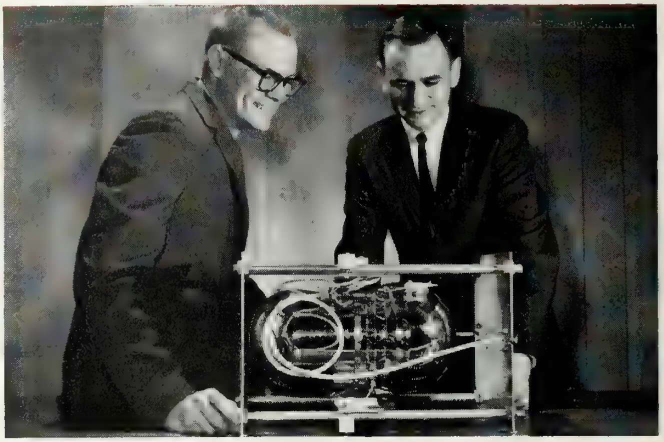
HYDRAZINE TESTS PROVE SUCCESSFUL

At press time, these significant milestones in hydrazine monopropellant control rocket system development had been passed:

- Proof of catalyst durability with successful motor firings of 3½ hours continuous operation and over 30,000 pulses.
- Good vacuum pulse performance and high response (see chart below).
- Pulse impulse bit repeatability within plus or minus 1%.
- Successful tests of advanced reactors from 0.10 to 100 lbs. thrust.
- Development and qualification of the first flight system employing the new catalyst (see photo).
- Demonstration of operation with catalyst and modified hydrazine propellants at temperatures from minus 65° to plus 165° F.



Experimental pulse performance as a function of commanded pulse width for cold bed starts.



FIRST FLIGHT SYSTEM:
RRC's Bill Smith and Bruce Schmitz, co-developers of Jet Propulsion Laboratory's Mariner and Ranger mid course correction hydrazine rocket, are pictured above with one of RRC's new satellite ACS now undergoing flight qualification.

ATTENTION: REACTION CONTROL SYSTEM DESIGNERS

For many years you may have been limited to hydrogen peroxide or liquid bipropellants for ACS applications. Now a monopropellant hydrazine system, perfected by RRC, offers competitive overall system weight and greater reliability than liquid bipropellants.

Monopropellant hydrazine offers higher performance than hydrogen peroxide due to the low molecular weight of its exhaust gases, and better handling and storability characteristics.

Because its exhaust gases have a low temperature, monopropellant hydrazine offers a degree of simplicity and reliability unattainable with high temperature liquid bipropellants — and performance is competitive.

Even higher performance and greater density potential will soon be available from the Hydrazine — Hydrazine Nitrate growth system now under development at RRC.

Write Rocket Research Corporation for "Designer's Check List", a comparison of H_2O_2, N_2O_4-Amine, and N_2H_4 ACS characteristics.

CALL ROCKET 2-1560 FOR MORE DATA

Ask for Bill Smith or Bruce Schmitz, get the complete hydrazine monopropellant rocket story. Or write today to

ROCKET RESEARCH CORPORATION

520 South Portland
Seattle, Washington 98108

Circle No. 9 on Subscriber Service Card

MARCH 22, 1965

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

HOUSTON PUBLIC

Sea Sparrow Considered For Point Defense Role

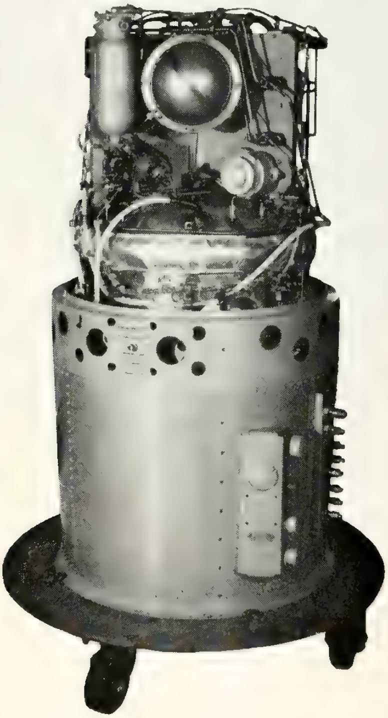
NASA Funding Bill Progresses

GE's High-Speed 18-lb. Computer

AF Plans for Orbiting Animals

Air Force Stacks Nikes For Re-entry Chute Tests

1,000 hour test proves: Apollo fuel cell can provide electrical power for lunar missions.



A flightweight PC3A-2 Apollo fuel cell powerplant designed and built by Pratt & Whitney Aircraft has successfully generated electrical power for more than 1,000 hours — almost 42 days — enough for more than two lunar missions.

Throughout the test, powerplant performance was consistent with the requirements established for units which will provide on-board electricity and drinking water for actual lunar missions.

This complete fuel cell powerplant has all the controls and auxiliary equipment needed for its operation without external control.

Testing was carried out in a sealed vacuum chamber simulating the conditions of space. Power demands during the test were scheduled to conform to a complete qualification endurance test for the lunar mission. This was followed by one simulated lunar landing power profile mission and part of another. At predetermined points during the test, a number of shutdowns and restarts were demonstrated to satisfy check-out requirements. As part of the test, the powerplant was operated at times under maximum emergency power conditions. This is the first time an automatic, self-regulating, fuel cell powerplant has accumulated more than 1,000 hours of operation.

The Apollo fuel cell system operates on hydrogen and oxygen, producing electricity directly from these elements without combustion. It will supply electrical power for life support, guidance, and communications equipment for the command and service modules of the manned Apollo spacecraft.

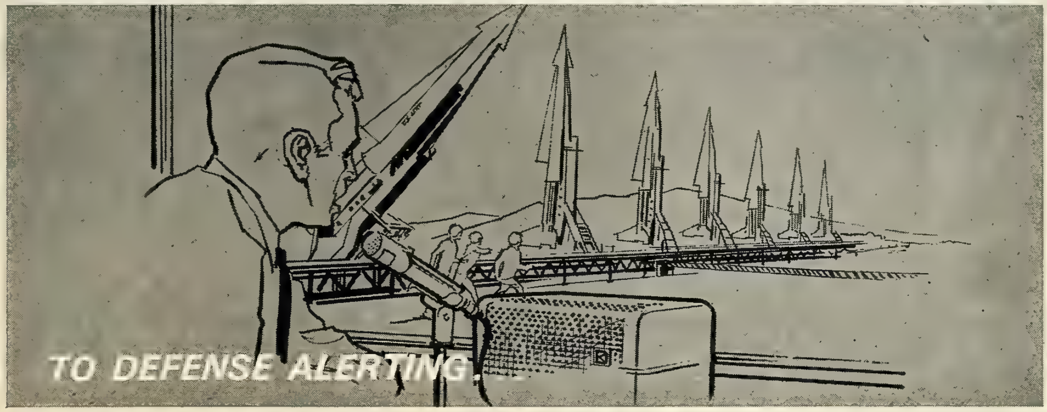
The unit was designed and is being developed by the Pratt & Whitney Aircraft division of United Aircraft Corporation for the Space & Information Systems division of North American Aviation, Inc., principal contractor to the Manned Spacecraft Center of the National Aeronautics & Space Administration for the Apollo command and service modules.

Pratt & Whitney Aircraft DIVISION OF UNITED AIRCRAFT CORPORATION

EAST HARTFORD, CONNECTICUT 06108

Circle No. 1 on Subscriber Service Card

FROM UNDERSTANDING . . .



DuKANE PROVIDES THE "VOICE" OF AUTHORITY!

Through the Defense Language Institute, the Armed Forces are being introduced to foreign languages and cultural enrichment. DuKane and Monitor Audio Learning Laboratories are playing a major role in this program. DuKane and Monitor Labs provide teaching in depth and accelerate individual learning capacities. Slower individuals receive more personal attention. The result is better understanding. DuKane Communications Systems such as private automatic telephones, intercoms and public address systems, are also turning in enviable, dependable performance records for keeping our defenses instantly alert. From understanding to defense alerting . . . DuKane provides the voice of authority. For details regarding DuKane-Monitor Audio Learning Labs or DuKane Communications Systems, contact the DuKane and Monitor Franchised Distributor nearest you . . . or write direct—no obligation!

DUKANE MONITOR

DuKANE / MONITOR®
LANGUAGE LABORATORY STANDARD OF THE WORLD

DUKANE CORPORATION
Communications Systems Division
DEPT. MR35, ST. CHARLES, ILLINOIS 60174

CS-112

Circle No. 2 on Subscriber Service Card

total capability, quick reaction in electronic countermeasures

Three Dynalectron divisions operate on an integrated system-management, quick-reaction team basis in the ECM field. On hand are highly qualified engineers and complete facilities with unique equipments for total program requirements, including all missile and space requirements. They can make available exclusive techniques for frequency testing, tuning, filtering, and circuitry. No matter what your ECM problem may be, the solution is available here:

Pacific Division

ECM engineering specialists for the design, development, and test of systems, components, and advanced modification programs, plus the finest ECM product line available. *Gardena, California.*

Cheyenne Division

Outstanding facilities and performance records in the manufacture of ECM products and installation prototypes for all types of production programs. *Airport Station, Cheyenne, Wyoming.*

Aerospace Operations Division

Quick reaction in retrofit/installation by fixed base or field team, from kit assembly through installation and flight test. *Fort Worth, Texas.*

d DYNALECTRON
CORPORATION
2233 Wisconsin Avenue • Washington, D.C. 20007

Qualified engineers and technicians are invited to submit resumes in complete confidence. An equal opportunity employer.

AND Missile range operation and data reduction • Electronics • Space technology and equipment

INSTRUMENT AND ELECTRONICS DIVISION
LAND-AIR DIVISION • MATTERN DIVISION • PARADYN DIVISION
HYDROCARBON RESEARCH, INC. • AIR CARRIER SERVICE CORPORATION

Circle No. 3 on Subscriber Service Card

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 12 March 22, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors

Charles D. LaFond............Electronics
William S. Beller................Engineering

Associate Editors

Lawrence J. Curran......Assistant Managing Editor
Heather M. David..................Space Medicine
Michael Getler.......................Electronics
John F. Judge................Propulsion/Materials
Robert L. Parker.......................Copy Editor
Rex Pay..................................Electronics
Hal Taylor.....................................NASA
James Trainor............................Military
Donald L. Zylstra.........................Military

Contributing Editors

David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach...................Art Director
Donald Strickland............Assistant Art Director
Suzanne Montgomery...........Editorial Assistant
Sally Fosnight.....................Editorial Assistant

BUREAUS

LOS ANGELES.....9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks....................Bureau Chief
NEW YORK...................20 East 46th Street
Michael Getler
CAPE KENNEDY................507 Orange Ave.
Merritt Is., Fla.
MIDWEST........................423 N. Quentin
John L. Zimmerman..............Wichita, Kan.
PARIS...........................11 Rue Condorcet
Jean-Marie Riche

EDITORIAL ADVISORY BOARD

Dr. Peter Castruccio
Alexander Satin
Conrad H. Hoeppner
Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton............National Sales Manager
Paul B. Kinney........Eastern Advertising Manager
Edwin J. Denker, Jr......Western Advertising Manager
Kenneth C. Blanchard.Marketing & Research Director
John N. Carlin..............Director of Circulation
Paddy Nelson................Circulation Promotion
R. Virgil Parker............Director of Production
Barbara Wiener........Advertising Services Manager

Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President........................ **Wayne W. Parrish**
Senior Vice President..............**Louis C. James**
Vice President.......................**Fred S. Hunter**

THE COVER

Two Nike missiles vertically joined for two-stage firing to test parachute deployment at high speeds. The Air Force Missile Development Center at Holloman AFB, N.M., is using Nike and Honest John missiles in a research program to develop a general purpose parachute for recovery of re-entry objects. The test parachutes and payloads are designed by Goodyear Aerospace Corp.

MARCH 22 HEADLINES

Goal of Ranger IX Will be Photos of Lunar Craters 10
Aeronutronic Gets Chaparral Award 10
Sea Sparrow Considered for Point Defense Role 14
NASA Funding Bill Progresses in House Committees 16
DOD Official Sees End of Spending Decline 17
Lockheed Tops DOD Contractor List for Third Year 21

SPACE SUPPORT

Goddard Facility Will Simulate Radiation Environment .. 24

SPACE ELECTRONICS

New Lightweight GE Computer Offers High Speed 28

SPACE MEDICINE

Air Force Plans Long-Duration Animal Satellite 32

ADVANCED MATERIALS®

Crystal Light Valves Offer High-Resolution Color TV 35

SPACE SYSTEMS

Capsule Probe of Mars in 1969 Remains Possibility 36

DEPARTMENTS

Letters 6
The Countdown 9
The Missile/Space Week® 10
Technical Countdown .. 23
The Industry Week 39
Contracts/Procurements 41
Products & Processes .. 42
Names in the News .. 44
When & Where 45
Editorial 46

48,000 copies this issue

letters

Project Firefly

To the Editor:

I have just read the article on the Firefly project ("Fireflies to Light the Way in NASA Effort to Chart Earth's Biosphere," M/R, March 8, p. 31) we are doing for and with the Goddard Space Flight Center. Thanks for another swell job of accurate technical reporting in an interesting manner.

Gilbert V. Levin, Ph.D.
Director of Special Research
Hazelton Laboratories, Inc.
Falls Church, Va.

Martian Debris Threat

To the Editor:

For some time I have entertained some disquieting thoughts regarding the near-space environment of Mars. There is some general acceptance of the theory that Phobos and Deimos are captured asteroids. However (based on conclusions drawn from a statistical analysis performed some years back), a double capture is somewhat unlikely for a planet as small as Mars. Instead, it might be that Mars originally had one moon of larger size than the present ones. Its origin may have been asteroidal or it may have been formed from the same material as Mars. Dr. Clyde Tombaugh has advanced the theory that some of the line markings on Mars were produced by asteroid collision. A collision between a small satellite and an asteroid of appropriate size could readily result in mutual disintegration. The satellite fragments having highly elliptical orbits would eventually end up in low circular orbits and spiral into Mars. The fragments with more circular orbits would survive. This would represent the respective cases for Phobos and Deimos.

If this has occurred, a potentially dangerous situation for Mars space flight exists. It would then be logical to suspect that Mars' two moons are but the astronomically visible portion of considerable debris. The total amount still left could be spread out as a low-density ring. Probably some of this material still occasionally enters Mars' atmosphere. Phobos is now near Roche's limit (5,300 miles from Mars' center) and, depending on its strength, may one day break up and add more debris. If it should break up at this limit, it need only drop another 500 miles in altitude to have this occur.

It might be worthwhile to re-examine Mars for faint satellites or ring material. Probably any such material is too small and widespread to telescopically detect, but the possibility of such a situation existing seems worth resolving prior to any manned expedition. Should *Mariner IV* fail near Mars, this could be rather suggestive of the proposed situation actually existing.

E. H. Dingman, Chief
Applied Physics Section
Martin Company
Denver, Colo.

Rockets for Ranger?

To the Editor:

Your March 1 editorial on *Ranger VIII* and the continuing debate on the nature of the lunar surface have renewed the speculation among some Air Force ROTC cadets and the staff at this detachment.

It is held that a small rocket armed with an explosive head and a flare or smoke marker could be fired along the camera axis in order to impact in the field of view prior to terminal photography by the *Ranger*. Possibly several rockets, with various fuze delays, could be thus employed and the resulting craters, should the explosion occur between exposures, would help settle the debate on the nature of the surface.

Certainly this procedure has been considered but rejected for technical reasons. Any information you are able to release concerning this approach may help terminate an endless discussion based entirely on conjecture.

Lt. Col. William C. Tinsley
Professor of Aerospace Studies
AFROTC
University of Pittsburgh
Pittsburgh, Pa.

NASA officials say they have received numerous suggestions that a projectile be put aboard Ranger for this purpose. They say there are three principal reasons why this is not feasible:

1) Several photos would be required to show the surface before, during and after impact. Ranger's rate of descent and rate of shuttering of cameras do not provide sufficient coverage to meet this requirement.

2) To be useful in such a project, the projectile would have to hit within the field of view of the cameras. The last picture on a Ranger flight, which offers the highest resolution, covers a fairly small area. Camera axes do not point directly along the line of flight and would not necessarily include the impact point of a projectile. Insuring the projectile's hitting within the field of view would be a difficult problem.

3) Separation of a projectile from the spacecraft, which is delicately balanced in the frictionless environment of space, would tend to produce an overturning moment that would have to be overcome by attitude-control jets. This could be reduced by balancing and alignment of the separation axis, but still might damage photographic quality by causing blurring or repointing the cameras.

NASA says such projectile experiments should be deferred until the more sophisticated Surveyor soft lunar-landing program is operational.—Ed.

Producibility Engineers

SR. PRODUCIBILITY ENGINEERS

Must be a high rate production specialist with experience in volume production (quantities of several thousand units per month) of battle field missiles, ordnance items, electronic devices or related products. Experience should include direct association with highly automated production facilities, conveyor systems, special material handling techniques and modern processing methods. Engineering degree with ten years applicable experience required.

FORGING SPECIALISTS

Experience required in design and fabrication of aerospace forgings. Ability to assist Product Design Engineers in the design of forgings and evaluate forging designs for best forging practices and applications. Engineering degree required, preferably in Metallurgy.

PRODUCIBILITY ENGINEERS

Minimum ten years experience in Aerospace Design or Producibility. Assist Product Design Engineers in selecting materials, processes and standards for McDonnell designed products. Perform design evaluations for best producibility concepts in planning, tooling, fabrication and assembly procedures. Engineering degree required.

For information on these and other positions not listed, send confidential resume to: W. R. WARDLE, Supervisor—Engineering Employment, Dept. PP-322 W.

MCDONNELL

P.O. Box 516 St. Louis, Missouri 63166
An Equal Opportunity Employer

Circle No. 4 on Subscriber Service Card

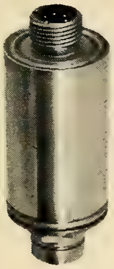
PRESSURE MEASUREMENT REPORT

CEC ▶

REPORT NUMBER 1

Meet CEC's multi-talented 4-361 Pressure Transducers

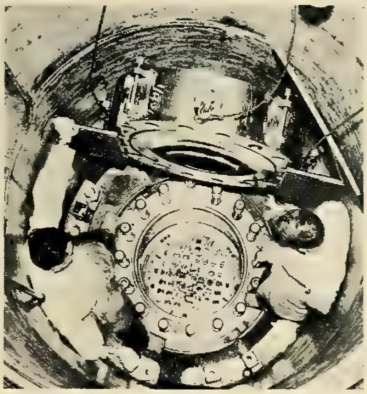
These advanced instruments are designed to function in nuclear radiation environments with simultaneous high temperatures or cryogenic temperatures. Each of the 4-361s provides a new spectrum of capability, accuracy and reliability combined within a single pressure transducer family.



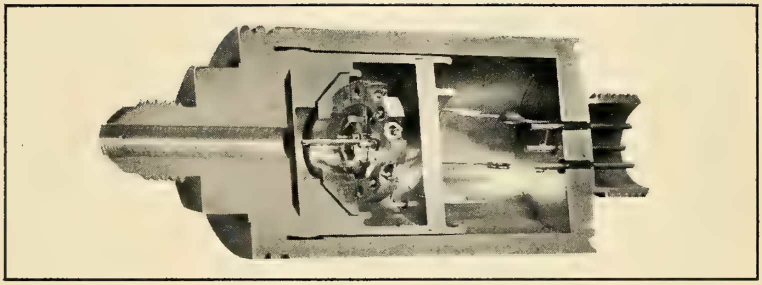
TYPE 4-361

A major advance in the 4-361's design is all-welded construction. Even the unbonded strain-gage sensing element (itself a unique one-piece unit) is welded to the transducer assembly and uses boron-free ceramic insulators for maximum reliability in nuclear radiation environments. *No* plastics, solders or organic materials are used in the construction of these instruments.

Result...both the high temperature (4-361-0001 & -0005) and cryogenic temperature (-0002 & -0006) models are capable of maintaining superior performance characteristics under broad temperature extremes, acceleration, vibration and shock. And—all have the capability for precision adjustment of sensitivity, residual unbalance, thermal zero shift and thermal sensitivity shift.



▣ The 40-mv output permits these transducers to be used in conjunction with all conventional measuring devices and signal conditioning equipment such as millivoltmeters, oscillographs, galvanometers, oscilloscopes and amplifiers.



▣ The 4-361 is a case in point why CEC has become the acknowledged leader in the field of pressure measurement.

Some significant specifications:

▣ **Pressure Range...**0-100 psi through 0-5000 psi absolute and gage. Standard ranges are 100, 250, 500, 1000, 2500 and 5000 psi. (0-100 psi through 0-1500 psi absolute and gage for cryogenic models).

▣ **Pressure Limits...**1.5 times rated pressure without calibration shift, and 2 times rated pressure without permanent damage.

▣ **Rated Excitation...** 10-v DC or AC rms; carrier frequency 0-20 kc.

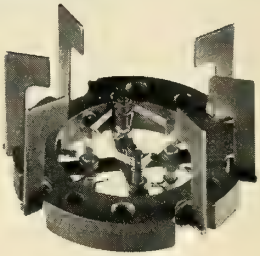
▣ **Input Impedance...**350 ohms nominal, 330 ohms minimum at 77°F.

▣ **Sensitivity...**40-mv +25% −10% open circuit at rated excitation and room temperature.

▣ **Combined Linearity & Hysteresis...** within ±0.75% of full range output (at zero pressure, rated excitation, and 77°F).

▣ **Output Impedance...**350 ohms ±10% at room temperature.

▣ **Compensated Temperature Range...** 77°F to 600°F (−320°F to +77°F for cryogenic models).



TYPE 4-361 SENSING ELEMENT

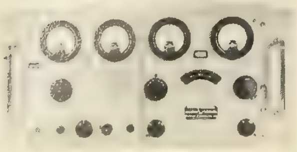
▣ **Operable Temperature Range...** −423°F to 700°F.

▣ **Weight...**9 ounces maximum, excluding mating electrical connector.

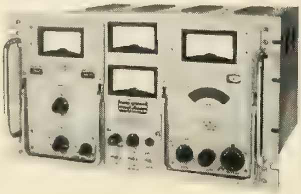
The 4-361s are part of CEC's complete line that ranges from primary and secondary pressure standards to operational transducers for any environment or application. For all the facts about these advanced new transducers, call or write CEC for Bulletin 4361-X4.

CEC
Transducer Division
CONSOLIDATED ELECTRODYNAMICS
A SUBSIDIARY OF **BELL & HOWELL**/PASADENA, CALIF. 91109
INTERNATIONAL SUBSIDIARIES: WOKING, SURREY, ENGLAND
AND FRIEDBERG (HESSEN), W. GERMANY

Circle No. 5 on Subscriber Service Card



- **TMR-2A:** 215 to 265 mc Tuning Range; VFO or XTAL controlled.
  FM or PM.
  FM demodulators—Wideband, Narrowband, Phase lock.
  Phase Demodulators—Short loop.
  Pre-D: Plug-in record and playback modules.



- **TMR-5A:** 55 to 2400 mc; Tuning Units VFO or XTAL controlled.
  AM/FM, PM.
  FM Demodulators—Wideband, Narrowband, Phase lock.
  Phase Demodulators—Short loop.

- **TMR-6:** 50 to 1000 mc; Fixed Frequency XTAL controlled
  RF Tuning Units. AM, FM or PM.
  FM Demodulators—Wideband, Narrowband, Phase lock.
  Phase Demodulators—Long loop.
  Pre-D: Plug-in record modules.

- **TR-101:** 100 to 2400 mc; Tuning Units VFO, XTAL controlled
  and Automatic Phase Control. AM, FM or PM.
  Dual Data Channels.
  FM Demodulators—Wideband, Intermediate, Narrowband.
  Phase Demodulators—Long loop, Short loop.

- **TR-711:** 100 to 2300 mc; Tuning Units VFO, XTAL controlled
  and Automatic Phase Control. AM, FM or PM.
  FM Demodulators—Wideband, Intermediate band, Narrowband.
  Phase Demodulators—Long loop, Short loop.
  Plug-in display unit or Pre-D record and playback modules,
  or oscilloscope.
- These receivers are compatible with TDC and DC series Diversity Combiners and the PRU-1 and PD-101 Predetection Record/Playback units. Plug-in IF bandwidth determining modules and plug-in demodulators are used in these receivers.

Other options are described in individual receiver data sheets.

DEI TELEMETRY RECEIVERS...

Technically Superior
Reliable by design
Modular for flexibility
Available now

Telemetry receivers are very important at DEI. Development and planning never stop. We consider new requirements, new components and the constant need to advance telemetry system performance. It is a rare telemetry receiving function that cannot be met by a DEI catalog receiver/module combination.

DEI receivers that have been in use for many years are updated by module changes to achieve new system characteristics. System modifications are introduced with minimum interruption when the DEI modular approach is used.

For your telemetry applications, consult DEI, the company where receivers and receiving systems are constantly being improved.

Write or call DEI for your copy of detailed specification sheets.

DEI
RESEARCH
DEVELOPMENT
MANUFACTURING

Defense Electronics, Inc.
Rockville, Maryland

ROCKVILLE, MD. (301) 762-5700, TWX: 302-427-4660; **SHERMAN OAKS, CALIF.** (213) 872-2870, TWX: 213-783-2742; **COCOA, FLA.** (305) 632-5400, TWX: 305-632-5442; **WILLOW GROVE, PA.** (215) 659-5051; **INT'L.,** ROCKVILLE, MD.; **CABLE:** DEIUSA

Circle No. 6 on Subscriber Service Card

The Countdown

WASHINGTON

Marshall Favored to Boss Saturn IB/Centaur

Look for the Marshall Space Flight Center to be picked as the center responsible for the *Saturn IB/Centaur* launch vehicle. While the decision may not be announced publicly for a few months, some NASA officials backing Lewis Research Center for the role now are avowedly pessimistic.

SRAM Definition Approval Coming Soon

DOD approval for the project definition phase of the *Short-Range Attack Missile (SRAM)* is expected next month by the Air Force. During testimony before the House Armed Services Committee, Lt. Gen. James Ferguson, AF deputy chief of staff for R&D, predicted DDR&E approval within a few weeks. *SRAM,* capable of deployment in both B-52 and F-111 aircraft, was described as a versatile short-range weapon for both strategic and tactical aircraft.

Alleged Phoenix Delays Discounted

Many Navy officials connected with development of the integrated F-111B-*Phoenix* aircraft/missile system profess not to worry over charges that *Phoenix* development is slowing the overall program. They say that even if Navy misses the current target date of late 1969 or 1970 for introduction of the system into the fleet, the advantages of careful development and integration outweigh any premium in early delivery. The F-4/*Sparrow* system is regarded as adequate for the 1960's. Meanwhile, redesign of the *Phoenix* rocket motor and case, while adding to R&D costs, will produce big long-term production savings by eliminating fabrication problems, Navy spokesmen say.

Voyager Re-entry Tests in 1968-69

NASA plans a program of re-entry tests for the *Voyager* spacecraft landing capsule in late 1968 and 1969. Capsules for the test will be sterilized in the same way planned for future, operational capsules so that sterilization methods can also be checked.

Scientist-Astronaut Candidates Trimmed

List of scientists being considered for inclusion in the astronaut program is down to 400, and the goal for the summer is to narrow this to a group of 10-20. Any scientist chosen will receive training in high-performance aircraft and will have to be able to perform all control and docking maneuvers on the *Apollo* and LEM, just in case he might have to bring the vehicle back alone.

Construction Starts on First TOS Station

Groundbreaking ceremonies for the first *TOS (Tiros Operational Satellite)* System command and data-acquisition station antenna were held last week. The 85-ft. dish antenna and communications station, to cost about $4 million, will be ready for inauguration of the *TOS* by the Weather Bureau early in 1966.

House Committeemen Show Knowledgeability

Observers have been impressed with the expertise and technical understanding with which the House Space Sciences and Applications subcommittee has conducted its hearings on the FY 1966 NASA funding authorization. Questioning has been led by chairman Joseph Karth (D-Minn.), Rep. Weston Vivian (D-Mich.), who has a Ph.D in engineering, and Rep. Charles A. Mosher (R-Ohio), a newspaper publisher.

INDUSTRY

NAA Putting Flying Lab on Sabreliner

North American Aviation's Autonetics Div. is equipping a Sabreliner to serve as a flying laboratory to study problems of low-altitude flight. It will be available to military agencies as well as industry. Some of the equipment on board includes low-light-level TV, infrared scanner, laser range finder, stabilized optics and a multimode radar.

Lewis Battery Qualifies for Mars

Lewis Research Center has successfully tested a low-temperature battery that could be used to help power capsules on the surface of Mars. The unit has performed flawlessly at a temperature of 100 degrees below zero.

Polaris Subs' Commercial Use Studied

The Naval Electronics Laboratory at San Diego has studied use of *Polaris* submarines as cargo carriers across the North Polar route and predicts high commercial potential in this short-cut to the Pacific. Main problem would be in establishing agreed-upon shipping routes for cargo-carrying submersibles in a region where the Soviet Union is highly vulnerable to submarine attack. The study suggested the feasibility of transporting medical drugs or precision equipment to under-developed nations without port facilities. Cargo would be fired out the *Polaris* missile tubes.

Norden Reports 40-W Microelectronic Amplifier

A 40-watt microelectronic amplifier using three interconnected integrated circuits within one package has been developed by Norden Div. of United Aircraft Corp. The company has also delivered a linear signal amplifier to MIT for the SABRE project. The latter device can withstand 10^{15} neutrons per square centimeter.

INTERNATIONAL

Successful Emeraude Launch Reported

A fourth test of the French *Emeraude* launch vehicle has been conducted successfully, according to the Paris newspaper *Le Monde*. French authorities refuse to release any information about testing of the vehicle—a biliquid rocket developed under sponsorship of SEREB. The report says the test took place at the Hammaguir launching base at the end of February. Another test is scheduled for the end of April. It's believed the fifth test will be necessary before the French feel they can begin to test simultanously the first stage *(Emeraude)* and the second stage *(Topaze)* of the *Diamant* satellite launcher whose three stages are to be used together at the beginning of 1966.

The Missile/Space Week

Chaparral Pact Let

Army awarded $1,492,660 contract to Aeronutronic Div. of Philco Corp. to begin design, development, fabrication and testing of a *Chaparral* forward-area air defense system.

A $500,000 letter contract was awarded earlier. *Chaparral* will use the *Sidewinder IC* in a multiple mount, possibly on an M113 vehicle chassis. Development firings of the missile from a ground launcher are under way at the Naval Ordnance Test Station, China Lake, Calif.

SNAP 10A Set for Flight

SNAP 10A, scheduled for its maiden orbital test early next month from Vandenberg AFB, Calif., will test the feasibility of a nuclear reactor system in space.

The event will mark the first time a nuclear reactor ever ventured above the Earth's atmosphere. Some of SNAP 10A's 500-watt electrical output will feed a battery, which, in turn, will drive an ion engine developed by Electro-Optical Systems, Inc. The rest of the power will drive scientific instruments aboard the satellite.

SNAP 10A, developed by Atomics International, converts heat to electricity by thermoelectric means. Last year, during hearings before the Joint Committee on Atomic Energy, the Committee insisted on the present flight test. The Fiscal 1966 AEC budget also calls for funds for a second flight test if the first one fails.

120-in. Motor Fired

The 120-in. solid motor successfully completed its third preflight rating test at Edwards AFB, Calif.

The 250-ton rocket, being developed by United Technology Center for the *Titan III-C*, was fired nozzle up for two minutes March 12. It developed a peak thrust of 1.25 million lbs. Another static test will take place later this month at UTC's Coyote, Calif., test site.

Ranger IX Seeks Lunar Craters

NASA plans to use the last spacecraft in the *Ranger* series to take photos of large lunar craters.

The *Ranger D* spacecraft was scheduled to be launched on March 21. If successful, it will be named *Ranger IX*. The March launch window for *Ranger* opened on the 19th and will close on March 26.

Among the craters NASA would like to photograph are Alphonsus, Copernicus, Kepler and Aristarchus. The specific target, however, will depend on the day of launch and the results of the mid-course maneuver.

Primary targets will be closer to the Moon's terminator, or shadow line, than were the targets for *Rangers VII* and *VIII*. Pictures taken closer to the shadow line will have sharper shadows and, therefore, more contrast and better definition of details.

Two previous *Ranger* flights have been completely successful. *Ranger VII* returned 4,316 high resolution photographs of Mare Cognitum, which is streaked with rays from the crater Tycho, on July 31, 1964. *Ranger VIII*, on Feb. 20, 1965, returned some 7,137 pictures of part of the Sea of Tranquility, revealing cratering and surface features similar to that photographed by *Ranger VII*.

ARC Tests New Motor

Atlantic Research Corp. has successfully test-fired a rocket motor that uses an advanced propellant containing beryllium.

The test—first for the 36-in. spherical rocket—took place at ARC's facility near Corolla, N.C. The motor burned for 43 seconds and met all specifications, the firm said.

The rocket is being developed under contract for Jet Propulsion Laboratory. The contract calls for design, fabrication and test firing of two rocket motors to meet requirements of the Advanced Surveyor Retro motor.

Shots of the Week

An LTV Aerospace Corp. crew successfully fired the Army's *Lance* tactical missile at the White Sands Missile Range, N.M., March 9. No explanation of why the firing was delayed from its original schedule of late February was offered, but the Army said all test objectives were met in the launch from a non-tactical launcher.

Lance is the first Army missile selected to use prepackaged, storable liquid propellant, and is designed to complement division field artillery and to extend the division commander's capability for nuclear and non-nuclear supporting fire. Major components include a warhead section, guidance package, fuel tankage and engine. The missile uses a new modified inertial guidance and control concept conceived and developed by the Army Missile Command.

GSE for the system includes a self-propelled launcher, a fully mobile lightweight launcher and transporter-loader. The system is carried on an XM667, a modified M113 full-tracked armored vehicle.

- The Navy successfully launched two *Polaris A-3* missiles from the nuclear submarine Nathanael Greene on March 15. One shot was made while the sub was submerged; the other from the surface.
- Two Air Force Strategic Air Command crews launched a *Minuteman* ICBM from Vandenberg AFB, Calif., March 16.

1970 Manned Fly-bys Urged

A program of manned planetary fly-bys beginning in the 1970's, utilizing *Saturn V/Apollo* hardware and carrying probes to be released and monitored, is recommended as a result of a study at NASA's Marshall Space Flight Center.

Jerry N. Smith of the center's Future Projects Office told the Aviation and Space Conference of the American Society of Mechanical Engineers in Los Angeles that such missions appeared desirable, perhaps necessary, for a number of reasons:

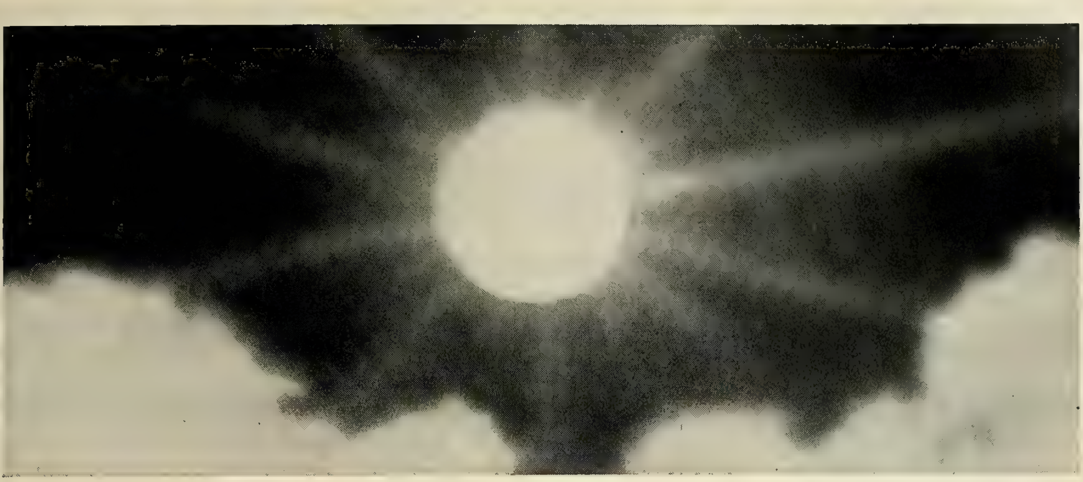
—Due to increasing energy requirements expected in the late 1970's, it is possible that manned orbiting and landing missions would not be performed before 1980.

—Considering the schedule of unmanned probes, it may not be wise to rely fully on them to prepare for manned missions to Mars and Venus. "Our success thus far with deep-space probes has been very discouraging," Smith said.

—By advancing technological capabilities by at least half, the cost of the fly-by missions would go directly into the cost of later landing missions. One estimate is that savings to the landing missions might be more than the total cost of the fly-by program.

—Considering costs and development time, it appears that from 1970 to 1980 there will be no missions except those based on *Saturn/Apollo* hardware.

The study suggests combining the advantages of unmanned probes,



Now...1000 hours of non-stop solar simulation...with the light that's **closest to the sun in spectral quality...!**

Newly-developed non-consumable negatives make possible this unprecedented continuous use of the carbon arc!

Now the testing of space vehicles and components and the precise calibration of solar cells is more accurate and dependable than ever before. Interruptions for recarboning every 20-24 hours have been eliminated . . . simulators get non-stop use of the light source that is the closest match to solar radiance in space.

Solar testing with "National" high-intensity arc carbons offers these important advantages:

- The same light intensity after 1000 hours as at start—at the same power setting.
- Higher power (32kw)—resulting in fewer modules per chamber.
- More economical to operate.

Write for your copy of "Studies in Spectral Energy Distribution of Different Light Sources in Connection With Solar Simulation."

UNION CARBIDE

"National" is a registered trade-mark of
UNION CARBIDE CORPORATION
CARBON PRODUCTS DIVISION
270 Park Ave., New York, N. Y. 10017
In Canada: Union Carbide Canada Limited, Toronto

Circle No. 7 on Subscriber Service Card

ME TARZAN!

Mighty for its size, this tiny explosive actuator can move as much as 20 pounds with only 1 amp firing current . . . safely, reliably.

It's just one of a variety of Atlas explosive actuating devices designed to transform a minute electrical impulse into a relatively more powerful mechanical force—to push or pull a mechanical load, operate a valve, release a latch, activate a gyro, or fire a primer or detonator.

Why explosive? Because explosive systems offer infinitely greater reliability . . . in smaller space . . . with less weight . . . and with lower power requirements than any other type of electromechanical system. Think of this when you work on one-time performance systems.

We make individual components. Or we combine these components with explosive switches or other mechanisms to form completely packaged actuating systems.

Why not call us today? Or as a start, send for technical literature containing characteristics and specifications.

ATLAS
CHEMICAL INDUSTRIES, INC.
Aerospace Components Division
Valley Forge, Pa. 19481

Circle No. 8 on Subscriber Service Card

including lightweight and non-recovery features, with the best features of manned missions, such as checkout, maintenance and repair capability.

Just before and during passage of the target planet, many probes, totaling about 10,000 lbs., would be released to perform various specialized tasks.

Later landing missions would profit not only from the planetary data, but also from crew training and experience, operational procedures and sub-systems operating experience, Smith said.

The study investigated two typical missions—a 1975 Venus fly-by of 380-394 days duration, and a 1978 Mars mission of 661-691 days. It assumed use of an *Apollo* Command Module and rendezvous and LOX transfer.

Republic Loses $8.8M

Republic Aviation Corp. has announced a loss of $8.8 million for 1964 compared to a 1963 net income of $3.6 million.

Sales for 1964 dropped to $297 million from $362 million in 1963; backlog was down from $270 million to $118 million.

The loss was attributed to excess costs on subcontract work from McDonnell Aircraft Corp. These costs are the subject of claims being reviewed and negotiated with McDonnell, Republic said.

Old Missiles Get New Jobs

Full utilization of *Atlas* and *Titan* ICBM's scheduled for phase-out by the Air Force this summer has been predicted by the San Bernadino Air Materiel Area.

The missiles will be put to use in anti-missile and space booster research and development assignments. It is also estimated that $500 to $800 million in assets will be recovered from disposition of the individual sites and equipment.

Officials report that requests have been received to use the silos as civil defense shelters and for storage of petroleum, gas and grain. The military services, NASA and other agencies have made claims for certain equipment. The remainder will be disposed of as surplus military equipment.

CPFF Pacts Down 28%

The trend away from cost-plus-fixed-fee contracts in the Dept. of Defense has resulted in a market share of a little over 10% of the annual procurement dollar for CPFF awards, industry officials were told at the DOD/NSIA Advanced Planning Briefings last week.

This is compared to the CPFF high point of 38% for the first nine months of FY 1961.

Order of preference for types of contracts are fixed-firm-price, fixed-price incentive, cost-plus-incentive-fee and CPFF, Defense officials said. Fixed-firm-price contracts rose from 31.5% in FY 1961 to 46.3% in FY 1964.

Aerospace Corp. Hearings Due

Congressional hearings on the Aerospace Corp., once scheduled for mid-February or earlier, may begin in mid-April, but the date is still uncertain.

The House Armed Services special investigations subcommittee, chaired by Rep. Porter Hardy (D-Va.), is being delayed by the military posture briefings, which are running about two weeks late in the Armed Services Committee. The committee is then expected to go directly into its military construction examination before freeing members for subcommittee duties.

Mariner Past Half-Way Point

The *Mariner IV* spacecraft has traveled more than half the distance it must cover to reach Mars.

Launched last Nov. 28 on a 7½-month 325-million-mile mission, *Mariner IV* had cruised more than 168 million miles by March 11, the 103rd day of its flight.

The spacecraft was 30,380,362 miles from Earth, traveling 25,250 mph relative to Earth. Its velocity relative to the Sun was more than 59,000 mph.

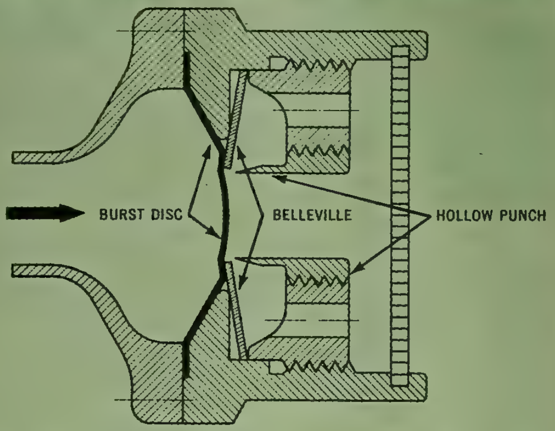
Project officials at the Jet Propulsion Laboratory said *Mariner IV* has made 16.5 million engineering and scientific measurements to date in nterplanetary space. The spacecraft s expected to radio back to Earth another 11 million readings before it lies by Mars July 14.

Mark II Fire Control Bids Due

Five companies will submit design proposals for the Mark II advanced fire control system for the F-111A.

Contracts totaling $3.8 million have been awarded to North American Aviation's Autonetics Div., General Dynamics/Fort Worth, Hughes Aircraft, Sperry Gyroscope and Westinghouse Electric Corp.

Burst-disc assemblies allow system operation within 5% of burst pressure



Capable of being set to burst with an accuracy of 1%, Calmec burst-disc assemblies can be used in systems operating up to 95% of rupture ratings, and can withstand repeated cycling.

Each assembly is pre-tested for rupture setting prior to shipment without damaging the burst diaphragm.

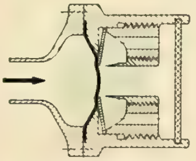
A burst disc assembly can be combined with a relief valve to guarantee zero system leakage up to the burst setting. After rupture, the relief valve can be used to conserve the system supply while maintaining overpressure protection.

Series 566 and 567 burst-disc assemblies are designed for use with most gases and special liquid applications; burst pressures to 3000 psi; operating temperatures from −65°F to +160°F. Units are available fully qualified for aerospace application.

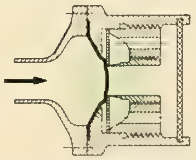
Custom designed assemblies can be made available with port sizes to 12 inches; pressures to 10,000 psi; and operating temperatures from −423°F. to +1000°F.

Write for 4-page brochure describing operation and specifications.

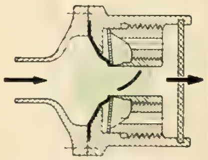
SEQUENCE OF OPERATIONS



Normal Position — Belleville spring provides partial backup of diaphragm; adjustment of spring permits accurate calibration of burst setting.



During Snap-Over — Burst diaphragm in contact with punch during snap-over of Belleville spring; pre-loading assures burst at desired pressure.



Full Diaphragm Shear — Belleville spring in snap-over position, complete rupture of burst disc center portion assures full flow area instantaneously.

PATENT NO. 3155271

CALMEC

CALMEC MANUFACTURING CORP.
5825 District Boulevard • Los Angeles 22, Calif. • (213) 588-6204 • TWX (213) 773-5796

Circle No. 9 on Subscriber Service Card

ASMS spinoff is alternative . . .

Sea Sparrow Eyed for Point Defense

Six to seven firms believed in competition with Raytheon, prime on existing Sparrow, for program definition award expected shortly

by Donald L. Zylstra

SEA SPARROW, otherwise known as Navy's basic point defense missile system concept, is one of two promising approaches to providing efficient point defense against air threats to small ships and fleet auxiliary vessels. *Sea Sparrow* will use the *Sparrow III* air-to-air missile adapted to a deck launcher aboard a surface ship.

A second method will employ components or technology evolved in the development of new shipboard concepts such as the *Advanced Surface Missile System* (*ASMS.*)

Navy research and development people have been directed to come up with a feasible point-defense concept that "would . . . replace the antiaircraft guns for self-defense of a ship, providing greater effectiveness and protection against the increasingly difficult targets no longer well-handled by guns," Robert W. Morse, Navy's assistant secretary for research and development, said.

"We are looking at a variety of alternative approaches that may lead to either a short-term or long-term solution, or both," Morse told the House Armed Services Committee.

• **The Sparrow route**—In the concept based on use of the *Sparrow III,* equipped with either 6A or 6B engines, the government would furnish the contractor with four major elements—the missile launcher, the *Sparrow III* missile, the fire control equipment and the non-expendable missile guidance equipment or radars.

Navy now is negotiating in a two-phase contracting process, with the award to be made as soon as evaluation of *Sea Sparrow* proposals is finished. The first-phase contract will call for complete definition of the system and the second phase will cover development, if the Navy approves of the *Sea Sparrow* approach to point defense.

Following requests for indications of interest from industry last October, 22 firms responded. Of these, 15 were invited to submit proposals in RFQ's mailed Dec. 8. Twelve of these attended a bidder's conference at the Naval Ordnance Laboratory, White Oak, Md., Dec. 14. Proposals due Jan. 18 have been received, and are being evaluated. Best information from Washington sources is that only six or seven firms submitted bids, no doubt assuming that Raytheon, prime contractor for *Sparrow III,* would have the inside track.

A contract calling for complete definition of *Sea Sparrow* presumably is now in the process of negotiation with Raytheon, with the award expected by the end of this month or the first week in April. General Electric and North American/Rocketdyne's McGregor (Tex.) facilities are logical candidates as propulsion subcontractors if Raytheon is awarded the prime contract for missile development.

Present Navy plans call for "a poor man's contract definition phase," with the system definition contract awarded to a single contractor—to be followed by a contract for full-scale development if Navy approves of the concept.

At least eight companies are bidding for a contract as the alternate source for *Sea Sparrow* propulsion, with technical proposals due at the Navy's Bureau of Weapons in Washington, D.C., Mar. 22. They include: Aerojet-General, Bermite, Canadian Bristol Aerojet, Lockheed Propulsion Co., Rocketdyne, Rocket Power, Thiokol and UTC.

Raytheon is assisting the Naval Missile Center in sea-firing tests of an experimental system, scheduled at the Pacific Coast facility by the Navy this spring. Both static and in-flight tests of these early models are planned—with completion and evaluation scheduled promptly, to permit the Bureau of Weapons to make a specific recommendation in June about whether or not the system should be developed.

Thus, by mid-summer the Navy hopes to make a decision about whether *Sea Sparrow* will be only a short-term solution to point defense, whether it can be the sole, long-term solution to this problem—or whether it will share point defense chores with some adaptation of the *ASMS,* also currently in the process of being defined.

• **Stock in hand?**—At present the Navy apparently hopes to restrict design to the use of *Sparrow III-6A,* or *6B.* Procurement of *Sparrow III* is scheduled to terminate with the Fiscal Year 1966 buy, but could be resumed if needed to provide missiles for the *Sea Sparrow* system. However, present planning seems predicated on supplying any surface-launching system from stocks now available.

A 3-in., 50-cal. twin gun mount is now being converted to the launcher Navy plans to furnish for the *Sea Sparrow* system. Work is being accomplished at the Puget Sound Navy Yard, Bremerton, Wash. This adaptation of the 3-in. mount probably will be configured to accept a total of eight *Sparrow III* missiles, boxed four on each side and poised for launching. Present specifications call for use of the *Sparrow* missile "absolutely unmodified." Fire control systems in existing ships would be adapted to be compatible with the *Sea Sparrow* system and might include refits of Mark 37, 51, 52, and 68 gear now installed in Navy vessels "Non-expendable missile guidance equipment" to be government-furnished would be largely existing air acquisition radar types, with even the possibility that optical guidance gear might be included for some applications of the system in ships. The main task of the prime and associated subcontractors for *Sea Sparrow* thus becomes one of fitting government-furnished components into a compatible system.

• **ASMS choice looms**—Navy's decision on *Sea Sparrow* will, of course, be influenced to a large degree on progress by mid-summer in the *ASMS* program Seven firms—Boeing, General Electric Hughes Aircraft, Raytheon, RCA Sperry Rand and Westinghouse Electric —have submitted pre-program definition studies which are now being evaluated. Navy's review of this work i scheduled for completion during Apri —after which DOD will decide for o against a project definition phase—possibly retaining either two or three firms in this next phase of the competition. ∎

Voyager Capsule RFP's Due in Summer

Spacecraft bus Phase I study to begin within two months; Newell testimony gives new details of plans for ambitious project

by Hal Taylor

NASA PLANS to issue RFP's for preliminary design of the *Voyager* landing capsule this August or September.

This will permit the agency to award incentive-type contracts for hardware development of both the capsule and the spacecraft bus in September, 1966.

Phase I of the spacecraft bus feasibility study will be initiated late in April or May. The program definition phase will begin about this September.

The Phase I preliminary design contractor for the lander will be picked by January, 1966.

Details of the expensive and complex *Voyager* program were revealed by Associate Administrator for Space Sciences and Applications Homer E. Newell in a report submitted to the House Space Committee.

He said that the contractor selected for the spacecraft bus hardware work will also be responsible for systems integration. Although Jet Propulsion Laboratory will have overall direction of the spacecraft bus work, NASA has not decided whether it or some other NASA center will be responsible for the capsulelander.

● **Fresh details**—The basic *Voyager* bus will weigh about 2,000 lbs. and be designed for either fly-by or orbiting missions. It will be about eight or nine feet in diameter and will carry 200-300 lbs. of scientific instruments. Systems and components of the bus are essentially *Mariner* spacecraft state of the art. Improvements will be sought, however, particularly in the data-storage and communications subsystems.

The spacecraft power system will consist of solar cells and batteries with a total capacity of 600 watts. Data storage capacity will be 10^8 bits. It will use an S-band communications system with a 10-ft. antenna and a capability of transmitting 2,000 bits of data per second.

The retro-propulsion module—which will be used to brake the spacecraft into Martian orbit—also is part of the spacecraft bus system. It will probably use space storable propellants with a thrust level of 1,500-2,000 lbs. Consideration is still being given to use of the Lunar Excursion Module's ascent engine, even though it has a higher thrust level. Depending on the mission, it will carry 2,200 to 4,400 lbs. of propellant, have a velocity of 7,120 to 10,600 ft./sec. and a burning time ranging from 390-780 sec.

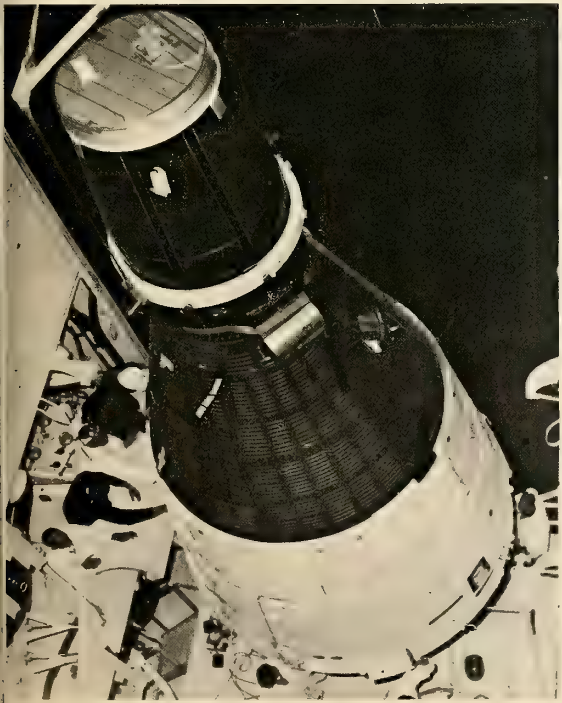
The third module in the *Voyager* spacecraft, the capsule landing system, probably will have an entry shape similar to that of the *Apollo* Command Module. Its weight will range between 1,000-6,000 lbs. during various parts of the program. About 10% of each capsule weight will be available for scientific experiments.

Because of the long (6-12 mo.) period the capsule will spend on the Martian surface, radioisotope thermo-electric generators will be required. It will have a power capacity of 300 watts. Its relay communications system will transmit 700 bits/sec. and direct transmission rate will be two bits/sec.

● **Launch slate**—Newell told the committee the *Voyager* flight program might include the following: in 1969, test flights of the bus; in 1971, the first operational missions involving an 1,800-lb. bus placed into orbit by a retro-propulsion unit. The orbit assumed is 1,000 x 4,000 KM.

The total spacecraft weight would be around 5,000 lbs., permitting several thousand pounds for the lander. However, it is anticipated that the first capsules should be less, possibly 1,000-2,000 lbs.

If this approach is to be followed, the 1973 missions could be an orbiter and a larger capsule. By 1975 a fly-by with a very large capsule of about 5,000-6,000 lbs. is planned. ■



Grissom-Young Capsule Ready

GEMINI spacecraft #3 is hoisted to whiteroom above its Titan launch vehicle at Cape Kennedy March 17, prior to mating for historic launch scheduled for March 23.

Mood is propitious . . .

NASA Funding Bill Advances in House

FY '66 requests moving through committees toward House vote before Easter; agency makes new pleas for big solid, SNAP 8, M-1

by Heather M. David

THE HOUSE Science and Astronautics Committee steps up work on the Fiscal Year 1966 NASA authorization bill this week in an atmosphere favorable to the space agency's requests.

NASA's expected space doubleheader, *Ranger* and *Gemini,* although it may not unduly influence members of the Space Committee who have long been familiar with the space program, cannot fail to impress junior members and create a conducive climate for House passage of the bill.

The Manned Spaceflight subcommittee, chaired by Rep. Olin Teague (D-Tex.), began marking up its portion of the bill last week. The Advanced Research and Technology subcommittee, chaired by Rep. Ken Hechler (D- W. Va.), puts its pens to the budget for the first time this week, and the Space Sciences subcommittee under Rep. Joseph Karth (D-Minn.) still has a few hearings to finish. Full committee markup is expected sometime the following week, with the bill going to the House floor before Easter.

Last week marked the last opportunity for the agency to drive home its plea for the three programs which were not in the budget request—the SNAP 8, 260-in. solid motor and M-1 engine.

Cancellation of the three programs has so far occasioned about a dozen speeches on the House and Senate floor, and the space committees have received a mass of correspondence and resolutions on one or more of the projects.

The committee now must decide whether to add funds to the FY '66 budget in the face of possible Presidential opposition, or even a repetition of the problem next year. Furthermore, House action would not assure Congressional approval. The Senate Space committee is considered to be more split on the programs than is the House group, and the Appropriations committees, which have the final crack, remain a question mark.

• **OART**—In sessions last week, Dr. Raymond Bisplinghoff, head of the Office of Advanced Research & Technology, and chemical propulsion chief A. O. Tischler told the committee that $41 million in government funds has been expended on the 260-in. solid, $30 million of which came from the Air Force.

The FY '66 request, had it been allowed by the Budget Bureau, would have been $20 million, Tischler said. With four years of sustained effort at roughly $20 million a year, he reported, the program could have been brought to a point where the motors would be useful to a flight system. That is, for $80 million NASA would be ready to proceed to design a flight system very rapidly.

He said that his own office, OART, and NASA as an agency were unanimous upon this course. He estimated that from this point, total cost of a flight system would be about $400 million, with just one motor. Some additional expenditure would be needed for handling facilities at the Cape. Witnesses said that in the long run, however, the solid boosters would be less expensive than liquid propellant.

Aerojet-General Corp. and Thiokol Chemical Corp. are estimated to have invested $36-40 million of their own funds. This includes $23 million or more for Aerojet, and $12.5-13 million for Thiokol. Closeout funds totaling $13.8 million for which NASA has asked reprogramming authority would be split about $6.7 million with Aerojet, $7.1 with Thiokol. However, no provision has been made to reimburse the contractors for spending on their own initiative because of their expectations for the programs in the future.

• **Some disagreement**—Atomic Energy Commission chairman Glenn T. Seaborg told the Senate Space Committee that there were possible alternatives to the ranking SNAP 8 system in thermoelectric and thermionic conversion cycles, which also could produce power in the tens of kilowatts region.

He said that it might be possible to develop thermoelectric power conversion systems by the early 1970's, and possibly thermionic conversion systems later which might be suitable for the purpose. "I am not convinced today that this particular system (SNAP 8) with this particular method of converting heat to electric power is the best way to develop power in the region of tens of kilowatts."

However, in House testimony, AEC-NASA nuclear programs chief Harold Finger said that there was no other power system comparable in size and weight with the SNAP 8 which would produce the same amount of power and be ready at the right time.

Finger said the program was only 20% complete with the FY '65 funds, and that total cost for development of a flight system would be $100 million. SNAP 8 offers the only power source suitable for a direct-broadcast TV satellite, for landing missions on the dark side of the Moon, and for missions beyond the Earth where the energy from the Sun decreases.

• **M-1**—Cost of work to bring M-1 to a flight program was estimated at $200 million. This would include $50 million in facilities and $150 million in research and development. The agency has already invested $90 million in facilities and $80 million in R&D, Tischler said.

However, there are other cutting-off points at which the program would yield useful data, he indicated. The next logical plateau beyond component testing, which the reprogramming request would cover, would be a complete systems test. This could be done in calendar year 1967, he said, at a cost of $60-70 million. Request for the M-1 engine, before BOB action, was $25.9 million for R&D plus $6.4 million in facilities, in the FY '66 budget.

Dr. Alfred Eggers, Deputy Associate Administrator of OART, said that carrying M-1 to a preliminary flight rating test would make it possible to have a very short response time in the event it was decided to go ahead with a mission requiring an exceptionally large payload in orbit or some deep space requirement. The same argument was used for continuing the large solid booster program to the PFRT stage. ■

Brown tells DOD/NSIA briefing . . .

DOD Spending Decline Is About Over

DDR&E chief sees stabilizing market, stresses opportunities in limited war equipments; Army details some tactical needs

by Michael Getler

NEW YORK—The Director of Defense Research and Engineering says that "by and large, the major part of the decline in defense business is now behind us . . . and that barring a major change in the international situation, the overall level of the defense program should remain fairly stable over the next few years."

As evidence of this leveling off, the Director, Dr. Harold Brown, reports that prime contract awards in the first half of Fiscal Year 1965 were about $900 million below the same period of FY '64, with all of the decline occurring in the first four months of this fiscal year. However, he said, "we estimate that for all of FY '65, prime contract awards may fall about $0.5 billion below FY '64. Therefore, we should be making up during the second half of FY '65 part of the decline relative to FY '64 which took place in the first half of the fiscal year."

Brown spoke last week to 1,200 attendees at the Dept. of Defense-National Security Industrial Assn. Advanced Planning Briefings here. Similar briefings were conducted earlier in Los Angeles (M/R, March 8, p. 12).

From the viewpoint of the defense industry, Brown said that actual prime contract awards "are perhaps the best measure of defense business trends."

"Evidence that the biggest part of the effects of the drop may be behind us also lies in the fact that employment in the defense-related industries has now stabilized after an 18-month decline," Brown reported. "Whether a new upward trend can be sustained is questionable," he added, "but it certainly appears that the major part of the adjustment to the decline in defense business has already been made."

Brown told MISSILES AND ROCKETS that, while the battles of the FY '66 budget still have to be fought, further evidence that DOD spending has reached the bottom of the decline is likely in the FY '67 budget, which is expected to be at about the same level as this year or possibly slightly higher. He pointed out that if the FY '67 budget did go up, it probably would still be less of a climb in percentage terms than that which the Gross National Product might take.

Brown also stressed that despite a period of relatively level activity, "there are a number of major program decisions yet ahead of us which could have important impacts on defense expenditures, particularly toward the end of the decade."

- **Key areas**—Brown said that in the category of general nuclear war, six major issues are involved in the FY '66-70 period (the same list was given earlier by Defense Secretary McNamara in Congressional testimony):

—Development and deployment of a new manned bomber, with an estimated five-year systems cost of $8.9-11.5 billion.

—The size of the strategic missile force. The estimated five-year cost of one type of increment—an additional 200 *Minuteman II* missiles—is $1.3 billion.

—The overall level of the anti-bomber defense program, with a five-year estimated cost of $300-350 million if units proposed for phase-out in FY '66 are retained.

—Production and deployment of a new manned interceptor, with an estimated five-year cost of $4 billion.

—Production and deployment of the *Nike-X* A-ICBM, with the cost of one possible deployment at $24 billion over a five-year period.

—Construction of fallout shelters for

Aerojet 260-in. Case Shipped after Test

THE 260-IN. maraging steel motor case slated for loading and firing late this summer is shown leaving by barge from Chester, Pa., on March 17, en route to Aerojet-General's Dade County, Fla., facility. It is to be loaded with 1,692,000 lbs. of solid propellant for the firing, in which it is to develop more than 3 million lbs. of thrust. Prior to shipment, 70-ton welded case was hydrotested at Sun Shipbuilding & Dry Dock Co. in Chester, where it was loaded with 160,000 gals. of fluid and pressurized to 738 psi, showing it is able to handle pressures it will later be subjected to.

260 DIA MOTOR
USAF
NASA

the entire population, with a combined cost of $5 billion.

• **Diminishing returns**—A nationwide civil defense program could reduce general nuclear war fatalities by about 30 million persons, DOD has reported, and a large, balanced damage-limiting program including anti-bomber and A-ICBM facilities could save an additional 40 million. However, Brown warns that there is no defensive program within this general range of expenditures which would reduce fatalities much below 80 million if the Soviets target their full attack on our cities so that U.S. missile forces could not play a major damage-limiting role by attacking Soviet missile sites.

"At each successively higher level of U.S. expenditures," Brown cautions, "the ratio of our cost for damage limitation to the potential aggressor's cost for assured destruction becomes less and less favorable for us. At the level of spending required to limit fatalities to about 40 million in a large first strike against our cities, we would have to spend on our damage-limiting programs about four times what the potential aggressor would have to spend on damage-creating forces." He adds that it is worth noting that the Soviets are faced with the same problem, "only much worse"—due to the U.S. strategic nuclear superiority.

Brown says that DOD analysis shows that even after absorbing a first strike, the programmed U.S. strategic *missile* force alone, if directed at the enemy's urban areas, could cause more than 100 million fatalities and destroy about 80% of his industrial capacity. He says that further additions to the force—either missiles or bombers—would add very little. He said a follow-on attack by presently programmed bombers would increase fatalities by only 10-15% and eliminated production by another 0.5%. The remaining strategic forces are being procured, he pointed out, because of their contribution to U.S. damage-limiting capability.

• **Tactical openings**—In terms of new business opportunity, Brown and Lt. Gen. William J. Ely, a deputy director of DDR&E, both made strong pitches for industry effort in the limited or tactical warfare area. Brown, in a departure from his text, promised "good future defense business for a sound and imaginative job by industry in this area."

Ely, before calling out some of these tactical needs, paused long enough to report that the level of DOD space expenditures, now about $1.7 billion annually "may increase to $2 billion annually in the foreseeable future."

The most important problem common to almost all tactical situations, Ely said, was that of target acquisition. Ely sees substantial gains in field radar weight, cost, reliability and maintainability beyond the progress to date.

Brown echoed this, saying that integrated circuits ought to be used more to achieve the redundancy needed for high reliability rather than merely to produce more complex equipment.

The same problem exists in the Navy, where planners see future shipboard detection systems involving fixed antenna arrays whose beams are electronically scanned and linked to a single high-capacity computer target analysis system.

The size, weight and power requirements of shipboard systems have cut deeply into the amount of equipment that can now be put aboard. The situation is intensified with more, higher performance targets to handle.

• **Specifics**—Among the other pregnant areas of tactical equipments listed by Gen. Ely were:

—Development by industry of an effective airborne track-while-scan radar for land surveillance and land target detection, as well as techniques for integration of inputs from many sensors, possibly with advance pattern-recognition techniques, to aid target evaluation.

—The problem of self-location to very precise coordinates—a major concern of both ground and air forces. On the ground, it is a key to good fire control; in the air, ASW planes need more precise navigation equipment—as do ships and helicopters.

—Overland mobility, all-weather, all-terrain-type vehicles.

—Anti-tank weapons that are simple, reliable and rugged, and possibly including terminal homing weapons which do not give away launch positions. Improvements are apt to cause a major shift in tactics in the future.

—Secure voice communications. "What we want," says Ely, "is a portable voice system, secure for about 72 hours, which gives us the same flexibility and convenience as an ordinary telephone—easy recognition, conference hook-ups and unrestrained switching. We'd like to see radical improvements in speech-processing techniques for narrow-band systems."

—Improved techniques to allow better matching of conventional ordance against targets—in addition to better control and instrumentation to support low-level air attack tactics.

—Lengthening the lifetime of aircraft rocket ordnance. At present solid propellants may become unreliable by just sitting on the shelf, DOD says.

—For counter-insurgency, new techniques for detecting people from the air or ground, especially those under foliage or in caves. Also sensors and methods for cache detection, underground tunnel detection and contraband detection in motorized or steel boats.

—Image intensification for night viewing. DDR&E would like to see goggles developed with 1,000-yard viewing range on a dark night, with a wide field of view and negligible weight.

• **Army spells it out**—An example of the ready market for tactical systems developments was illustrated most candidly in the Army portion of the briefings. Overall Army procurement from industry in FY 1966-70, excluding construction, should total more than $20 billion, with about $3-4 billion going to R&D, according to Army planners.

The Army's Electronics Command at Ft. Monmouth, N.J., reports that about $100 million has been allotted for external spending "over the next several years" for R&D in tactical communications with "much greater sums slated for equipment procurement."

For example, Army will spend $15 million for new 300-line solid-state transportable switchboards and over $400 million for new FM combat radio sets. Another $100 million will be spent on a new family of radio relays and multiplexers which provide up to 96 channels. SSB transceivers for vehicles will amount to more than $50 million in new business. The Army says it also plans to spend some $15 million annually for several years for new multichannel *troposcatter* sets for division and corps field use, able to provide up to 12 channels for transmission distances up to 150 miles with no relays.

For the European troposcatter program, part of the STARCOM network, Army says more than $0.5 billion is expected to be spent over the next several years.

For combat surveillance, Army will spend $150 million in R&D plus substantial equipment buys, estimated at over $100 million including man-pack radar, airborne systems for the OV-1 Mohawk, possibly new unmanned reconnaissance systems such as the MQM-58A and laser surveillance and communications systems.

Tentative Army plans also call for $50 million in avionics R&D contracting in the next several years, with equipment purchases estimated to run at about $12.5 million annually. Another $75 million has been allotted for out-of-house R&D in components during the same period.

Army Missile Command, which will spend about $750 million with industry in FY '66 for missile and rocket programs (M/R, Mar. 8, p. 12), with about 50% of it going to R&D, has also set forth a major challenge to industry for advanced field missile fire systems, particularly anti-tank weapons. The Army is interested in lightweight direct-fire systems which allow gunners to take tanks that they can see without having to provide guidance to impact. ■

Third time running . . .

Lockheed Tops DOD Contractor List

LOCKHEED AIRCRAFT CORP. for the third consecutive year topped the list of 100 leading prime United States defense contractors in Fiscal Year 1964, receiving awards totaling 5.8% of the U.S. total with $1,455,000,000. Boeing retained its second-place standing as in FY '63, with $1,365,200,000 for 5.4% of the nation's total.

Third place honors changed hands in FY '64, with McDonnell Aircraft Corp. moving into that standing from ninth position in FY '63.

Only the first four primes listed contract awards totaling more than $1 billion in FY '64 in contrast to five contractors in the billion-dollar class in FY '63, reflecting a decline in the overall awards total. Prime contractors in the top 100 received $670,300,000 less in DOD awards in FY '64 than in the preceding fiscal year, with the total dropping from $25,834,000,000 to $25,163,700,000.

The first 10 firms listed had 1.7% more of the prime contracts total in FY '64 than in FY '63, with the remaining companies on the list of 100 showing an overall decrease of 2.2%. DOD spokesmen noted that about half of the military work of the prime contractors listed is subcontracted, with about 40% of all subcontracts going to small business firms.

Nineteen companies were listed in FY '64 that were not included on the FY '63 list. More than half of the firms listed were engaged in missile-space, aircraft and electronics work in FY '64.

DOD LIST OF FY 1964 100 TOP PRIME CONTRACTORS

Rank	Companies	Millions of Dollars	Percent of U.S. Total	Cumulative Percent of U.S. Total
	U. S. TOTAL	**$25,163.7**	**100.0%**	**100.0%**
	100 COMPANIES, TOTAL	**18,484.8**	**73.4**	**73.4**
1.	Lockheed Aircraft Corp.	1,455.4	5.8	5.8
2.	Boeing Co.	1,365.2	5.4	11.2
3.	McDonnell Aircraft Corp.	1,157.4	4.6	15.8
4.	North American Aviation, Inc.	1,019.5	4.1	19.9
5.	General Dynamics Corp.	986.7	3.9	23.8
6.	General Electric Co.	892.6	3.5	27.3
7.	American Telephone & Telegraph Co.	635.6	2.5	29.8
8.	United Aircraft Corp.	625.4	2.5	32.3
9.	Martin Marietta Corp.	476.2	1.9	34.2
10.	Newport News Shipbuilding & Dry Dock Co.	400.2	1.6	35.8
11.	Grumman Aircraft Engineering Corp.	395.6	1.6	37.4
12.	Sperry Rand Corp.	373.9	1.5	38.9
13.	General Tire & Rubber Co.	364.4	1.5	40.4
14.	International Business Machines Corp.	332.4	1.3	41.7
15.	Hughes Aircraft Co.	288.7	1.2	42.9
16.	Avco Corp.	278.7	1.1	44.0
17.	Bendix Corp.	257.4	1.0	45.0
18.	International Telephone & Telegraph Corp.	256.1	1.0	46.0
19.	General Motors Corp.	255.8	1.0	47.0
20.	Thiokol Chemical Corp.	253.6	1.0	48.0
21.	Raytheon Co.	253.0	1.0	49.0
22.	Ling-Temco-Vought, Inc.	247.5	1.0	50.0
23.	Westinghouse Electric Corp.	236.9	1.0	51.0
24.	Radio Corp. of America	233.6	1.0	52.0
25.	General Telephone & Electronics Corp.	228.7	0.9	52.9
26.	Textron, Inc.	216.3	0.9	53.8
27.	Ford Motor Co.	211.2	0.8	54.6
28.	Litton Industries, Inc.	210.0	0.8	55.4
29.	Douglas Aircraft Co.	203.2	0.8	56.2
30.	Chrysler Corp.	170.2	0.7	56.9
31.	Northrop Corp.	164.9	0.7	57.6
32.	Pan American World Airways, Inc.	164.4	0.7	58.3
33.	Standard Oil Co. (New Jersey)	161.2	0.6	58.9
34.	Kaiser Industries Corp.	151.7	0.6	59.5
35.	F M C Corp.	141.4	0.5	60.0
36.	Hercules Powder Co.	136.9	0.5	60.5
37.	Collins Radio Co.	129.0	0.5	61.0
38.	General Precision Equipment Corp.	125.2	0.5	61.5
39.	Standard Oil Company (California)	122.4	0.5	62.0
40.	Morrison-Knudsen Co., Inc.; Utah Construction & Mining Co.; Perini Corp.; and C. H. Leavell & Co.	121.5	0.5	62.5
41.	Honeywell, Inc.	107.5	0.4	62.9
42.	Texaco, Inc.	105.7	0.4	63.3
43.	Massachusetts Institute of Technology	98.2	0.4	63.7
44.	Socony Mobil Oil Co.	79.4	0.3	64.0
45.	Aerospace Corp.	76.2	0.3	64.3
46.	Thompson-Ramo-Wooldridge, Inc.	74.3	0.3	64.6
47.	Continental Motors Corp.	70.6	0.3	64.9
48.	Magnavox Co.	69.4	0.3	65.2
49.	Du Pont (E. I.) de Nemours & Co.	69.1	0.3	65.5
50.	Goodyear Tire & Rubber Co.	68.4	0.3	65.8
51.	Republic Aviation Corp.	66.9	0.3	66.1
52.	Olin Mathieson Chemical Corp.	66.2	0.3	66.4
53.	Burroughs Corp.	65.4	0.3	66.7
54.	Morrison-Knudsen Co., Inc.; Perini Corp.; and Hardeman (Paul), Inc.	64.9	0.3	67.0
55.	Western Union Telegraph Co.	59.0	0.2	67.2
56.	Lear-Siegler, Inc.	58.9	0.2	67.4
57.	International Harvester Co.	55.8	0.2	67.6
58.	Johns Hopkins University	54.9	0.2	67.8
59.	System Development Corp.	53.6	0.2	68.0
60.	Curtiss-Wright Corp.	51.2	0.2	68.2
61.	American Machine & Foundry Co.	50.6	0.2	68.4
62.	Day & Zimmerman, Inc.	48.6	0.2	68.6
63.	Signal Oil and Gas Co.	47.7	0.2	68.8
64.	Asiatic Petroleum Corp.	45.3	0.2	69.0
65.	Sverdrup & Parcel, Inc.	44.9	0.2	69.2
66.	Cutler-Hammer, Inc.	43.0	0.2	69.4
67.	Shell Caribbean Petroleum Co.	42.3	0.2	69.6
68.	Kaman Aircraft Corp.	42.1	0.2	69.8
69.	Atlantic Research Corp.	41.5	0.2	70.0
70.	Eastman Kodak Co.	41.4	0.2	70.2
71.	Control Data Corp.	41.2	0.2	70.4
72.	Continental Oil Co.	39.7	0.2	70.6
73.	Hayes International Corp.	35.8	0.1	70.7
74.	Hardeman (Paul), Inc.; Concrete Industries	35.0	0.1	70.8
75.	Cities Service Co.	34.7	0.1	70.9
76.	Hazeltine Corp.	34.6	0.1	71.0
77.	Mitre Corp.	34.5	0.1	71.1
78.	Westinghouse Air Brake Co.	34.4	0.1	71.2
79.	United States Steel Corp.	34.0	0.1	71.3
80.	Texas Instruments, Inc.	33.0	0.1	71.4
81.	Vitro Corp. of America	32.9	0.1	71.5
82.	Richfield Oil Corp.	31.8	0.1	71.6
83.	Standard Oil Co. (Indiana)	31.3	0.1	71.7
84.	Union Oil Co. of California	31.3	0.1	71.8
85.	Bethlehem Steel Corp.	30.7	0.1	71.9
86.	Electronic Communications, Inc.	30.6	0.1	72.0
87.	American Bosch Arma Corp.	30.0	0.1	72.1
88.	American Ship Building Co.	29.7	0.1	72.2
89.	Firestone Tire & Rubber Co.	29.6	0.1	72.3
90.	Gyrodyne Co. of America, Inc.	29.2	0.1	72.4
91.	Stanford Research Institute	28.7	0.1	72.5
92.	Hardeman (Paul), Inc. & Morrison-Knudsen Co., Inc.	27.4	0.1	72.6
93.	Fairchild-Hiller Corp.	27.3	0.1	72.7
94.	Sinclair Oil Corp.	26.6	0.1	72.8
95.	Kiewit (Peter) Sons' Co.	25.9	0.1	72.9
96.	Ryan Aeronautical Co.	25.0	0.1	73.0
97.	Dynalectron Corp.	25.0	0.1	73.1
98.	Sanders Associates, Inc.	24.5	0.1	73.2
99.	Universal American Corp.	24.5	0.1	73.3
100.	Leavell, C. H., Co. & Kiewit (Peter) Sons' Co.	22.9	0.1	73.4

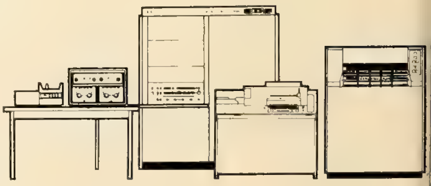
Too bad about your IBM 1620

We didn't set out to make your 1620 system obsolete. But facts are facts. And, fact is, you can replace your 1620 to great advantage with an SDS system. What does that buy you? Plenty: *at least four times the throughput at 25% less cost.*

A typical SDS system consists of an 8K memory SDS 910 computer with Magpak magnetic tape system, line printer, 100-card-per-minute reader and Teletype keyboard/printer with paper tape reader/punch. It leases for $3,041/mo. and does everything your 1620 does, faster. You can use the MONARCH monitor routine and FORTRAN, SYMBOL or METASYMBOL. You can batch process programs written in FORTRAN and/or METASYMBOL automatically and interchangeably. And your throughput will be from 4 to 22 times faster.

For additional capacity and speed you can use an SDS 920, 925 or 930 system. The monthly lease prices are $3,281, $3,411 and $3,541 respectively. And no matter which SDS system you order, the benefits are the same: a better system with greater efficiency for fewer dollars.

Want concrete proof? We're planning a demonstration in a city near you soon. For details, pick up a phone or drop us a line.



SDS SCIENTIFIC DATA SYSTEMS 1649 Seventeenth Street, Santa Monica, Calif.

Sales offices in New York, Boston, Washington, Philadelphia, Pittsburgh, Huntsville, Orlando, Chicago, Houston, Albuquerque, San Francisco. Foreign representatives Instronics, Ltd., Stittsville, Ontario, CECIS, Paris; F. Kanematsu, Tokyo; RACAL, Sydney

Circle No. 10 on Subscriber Service Card

Technical Countdown

ASTRONAUTICS

LEM Radiation Shielding Negligible

The relatively thin shielding offered by the *Apollo* Lunar Excursion Module against solar protons is indicated by a Manned Spacecraft Center analysis that shows that a particle flux producing a 1-rem dose in the *Apollo* Command Module will produce a 17-rem dose in the LEM. The *Apollo* space radiation warning system will provide advance indication of need for astronauts to return from the LEM to the Command-Service Modules. From the time that the astronauts leave the Command Module for lunar exploration, they will be virtually naked to solar proton radiation. ASRWS is expected to provide optical telescopes at Carnarvon, Australia; Canberra, Australia; Hawaii; Guaymas, Mexico; Houston, Texas; Madrid, Spain; and Tananarive, Republic of Malagasy. Radio telescopes probably will be located at Canberra, Houston and Madrid.

Ranger Pictures Suggest Comet Impact

Ranger VII photographs suggest that the lunar crater Tycho was produced by impact of a comet, says Professor Harold C. Urey. He deduces this from the energy with which material has been ejected into the surrounding maria. Impact of a relatively low-density comet should produce high-temperature gas that acts more like a propellant than a detonation, says Urey. He said the 1908 Siberian event was thought to have been a small comet that never got to Earth, and this suggested that cometary inpact would not be a rare process on the Moon.

PROPULSION

Wafer Motor Restarted in Altitude Test

Lockheed Propulsion Co. engineers have fired their solid-propellant, pulsed wafer motor 40 times on command at a simulated altitude of 100,000 ft. The successful test duplicated the earlier ambient pressure firing of the motor. The unit was set up in a large altitude chamber at the Air Force's Arnold Engineering Center. It contained 40 separate propellant wafers, each separated by only a thermal barrier and each with its own igniter. Each pulse lasted several seconds generating more than 1,000 lbs. thrust. After every five pulses, the motor was inspected before the test continued. LPC is developing a second impulse-controlled rocket motor tailored specifically to air-launched missile requirements.

Submerged Nozzle Pintle Valve Tested

A pintle valve developed for use with submerged rocket nozzles using chamber-bleed, hot gas secondary injection withstood a 50-second cycle duration at temperatures exceeding 5,700°F. The pintle valve was modulated throughout the test at Thiokol's Wasatch Div. by an external actuator following a predetermined duty cycle. The pintle itself is made from porous refractory metals impregnated with copper to provide transpiration cooling during operation. A pintle valve with an internal actuation system will be tested on a 5,000-lb. solid motor in the near future. Total weight of the valve and actuator is less than 4 lbs. with a valve leakage rate under 3% at maximum flow rates.

Glass Motor Cases Flush-Cleaned

Propellant can be removed from glass-wound plastic motor cases through a hydraulic process developed by Byron Jackson Inc., Long Beach, Calif. The Borg-Warner subsidiary recently completed cleaning and restoring a *Polaris A-3* second stage motor case in an evaluation program for the Navy. The firm earlier cleaned out the propellant from a *Polaris A-3* first stage case. The process is similar to the one developed by the firm for restoring metal motor cases and involves pumping water at high pressures through cutting heads.

ELECTRONICS

Sensitive Radio-Astronomy Antennas Needed

Dynamic motion and shape of solar corona as well as the nature of planetary ionospheres and surfaces could be examined if larger ground-based radio-astronomy antennas were available, claims Professor Von R. Eshleman of the Center for Radar Astronomy, Stanford University. What is needed is a system with sufficient sensitivity to obtain reasonable signal-to-noise ratios without integration. Planets and the inter-planetary medium over essentially the whole of the solar system could be brought under intensive radar investigation utilizing a combination of deep space probes, powerful transmitters, and large antennas situated on Earth, claims Eshleman.

Ranger Pinpoints DSIF Stations

As a result of *Ranger VI* and *Ranger VII* tracking data, DSIF station locations can be determined to within 10 meters in the radial direction normal to the Earth's spin axis. Differences in the longitude between stations can be calculated to within 20 meters. The radius of the Moon has been found to be about 3 km less than was thought, and knowledge of its mass has been improved by an order of magnitude. W. L. Sjogren and D. W. Trask of JPL point out that slow relative motion of points on the Earth's crust may limit accuracy of DSIF station location to 5 meters in the difference in longitude between stations.

LEM to Use EL Descent-Speed Display

An electroluminescent five-digit numerical display for the *Apollo* Lunar Excursion Module will be built by Sylvania Electric Products, Inc., for NASA to indicate relative descent speed. Under the $515,000 contract, awarded by Grumman Aircraft Engineering Co., LEM prime contractor, Sylvania will deliver 34 of the panel instruments. Requiring negligible power, the 2 x 4-in. flat readout devices will withstand extreme shock and vibration and exhibit no effects due to gravity-field irregularities, the firm disclosed.

Norden Presses Microelectronics Developments

A 40-watt microelectronic amplifier using three interconnected integrated circuits within one package has been developed by Norden Division, United Aircraft Corporation. The company also has delivered a linear signal amplifier to MIT for the SABRE project. This amplifier is reportedly capable of withstanding 10^{15} neutrons per square centimeter.

Lab To Simulate Radiation Environment

Goddard facility will employ three electron and proton accelerators and a cobalt-60 area to test spacecraft

by William S. Beller

THE OFTEN FATAL stabs of electron and proton streams on satellites may be blunted by a radiation environment facility now going up at Goddard Space Flight Center.

Explorers XV and *XIV*, *UK-1*, *TRAAC*, *Transit IVB* and *Telstar 1* have all fallen prey to radiation damage. The problem is that the spacecraft could not be adequately tested for radiation weaknesses except in space.

The Goddard facility, costing almost $2 million, is expected to be operating late next year or early in 1967. It will be the first facility that will be able to assess aspects of radiation damage on an entire spacecraft short of putting it into orbit, and able to irradiate sizeable portions of the spacecraft simultaneously with electrons and protons without scanning.

Goddard scientists are quick to praise the work of contractors who are studying the radiation effects on components destined for space flight. Unfortunately, however, these studies are made in research facilities that cannot closely simulate the space environment and electronic conditions under which a spacecraft will fly. Another drawback is that research facilities are not normally available for long-time environmental testing.

- **Three accelerators and Co-60**—The Goddard radiation environment facility was designed to provide electrons and protons in an energy range characteristic of orbital altitudes and most damaging to electronic devices. William Price, head of the radiation environments group, said that criteria for accelerators were set up after analyzing the damage produced in semiconductor devices exposed to various amounts and intensities of radiation in the laboratory, and relating these results to radiations in space.

To simulate the conditions for ionization damage in solid-state devices, the facility will also include a 30,000-curie cobalt-60 area in which spacecraft the size of the *Orbiting Astronomical Observatory* can be irradiated. The actual area exposed to the gamma-ray emissions of cobalt-60 will be 8 x 10 ft.

Price said it became clear after looking at the damage results and the amount and kinds of radiation at orbital altitudes that electron energies up to about 4 Mev are the most lethal. This figured in the decision to have three accelerators in the facility: a 0.5-3-Mev electron accelerator, a 0.5-4-Mev proton accelerator, and a 0.1-1-Mev proton-electron accelerator. High Voltage Engineering Corp. holds the contract for the latter accelerator. The other accelerators and the cobalt-60 machine will shortly go out for bids.

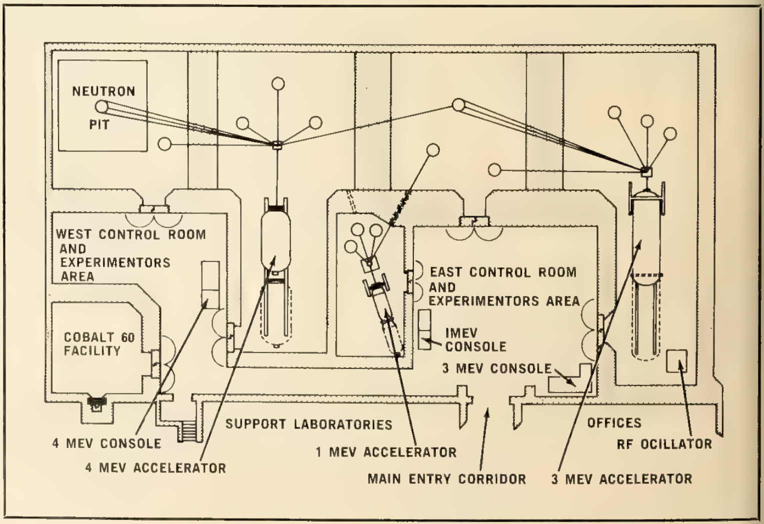
Multiple accelerators will permit irradiating a single target with two or three beams of electrons, or with a combination of electrons and protons. This will lead to closer simulation of the space radiation environment, and is a unique feature of the facility. If, for instance, all three accelerators are run simultaneously in appropriate electron modes, a good approximation can be made of the electron field in space. Similarly, protons can be introduced to give an even fuller picture of the particulate space radiation.

In usual laboratory work, the procedure is to irradiate a specimen with *either* electrons or protons, not both at the same time. The difficulty is that two machines are needed to make both types of particles flow simultaneously toward a target.

Price questions whether a stream of both electrons and protons hitting an electronic component might not have an effect different from a stream of only one kind of particles. He told MISSILES AND ROCKETS there is no reason to expect that there will be a difference, "but at the same time, no one has shown there won't be."

- **Example of facility use**—In a typical radiation experiment at this new facility, one machine would generate low-energy protons and the other two, appropriate sets of electrons. The low-energy protons can do considerably more damage than the high-energy ones

Diagram of radiation environment facility presently under construction at the National Aeronautics and Space Administration's Goddard Space Flight Center, Md., showing three accelerators and cobalt-60 area.



Common carrier for space

Titan III is available now; who needs it?

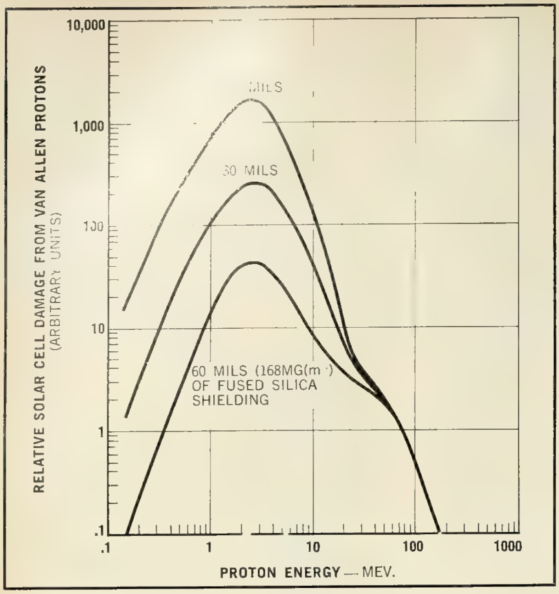
Ask the payload builder who has microminiaturized about as far as he can—and still needs more thousands of pounds of thrust. Ask the scientist who has a deep-space experiment to perform—with no cost-effective method of implementing it. Ask the military man who is concerned about mission flexibility. Ask the planners of the functional payloads which already have been scheduled for orbit aboard Titan III.

The U.S. Air Force Titan III combines the best in liquid and solid fuel technology. Precise launch capability. Cost effective. Reliable. Man rated. Flexible. Thrust range, depending upon configuration, from 500,000 pounds to nearly 2.5 million pounds. Handles payloads ranging up to ten tons for a 200-mile earth orbit or two-and-one-half tons for a moon shot. It's available now.

Get the facts on Titan III—a common carrier with uncommon capabilities. Write on company letterhead to Department RC-401, Martin Company, Friendship International Airport 40, Maryland.

MARTIN MARTIN MARIETTA

Circle No. 11 on Subscriber Service Card



SUMMARY OF MAXIMUM SPACE RADIATION FLUXES

NATURAL SOURCES:

	LOW ENERGY	HIGH ENERGY
PROTONS	120 Kev $<E<$ 4.5 Mev $\sim 10^8$ PROTONS/cm^2-sec.	30 Mev $<E<$ 700 Mev 2-4 $\times 10^4$ PROTONS/cm^2-sec.
ELECTRONS	110 Kev $<E<$ 1.6 Mev $\sim 10^8$ ELECTRONS/cm^2-sec.	1.6 Mev $<E<$ 5 Mev $\sim 10^5$ ELECTRONS/cm^2-sec.
	$E>$ 10 Kev $\sim 10^9$ ELECTRONS/cm^2-sec.	$E>$ 5 Mev $\sim 10^4$ ELECTRONS/cm^2-sec.
SOLAR FLARES	$E>$ 30 Mev $\sim 10^4$ PROTONS/cm^2-sec. (1000 sec.) [TOTAL DOSE $E>$ 30 Mev $\sim 10^9$ PROTONS/cm^2]	

ARTIFICIAL SOURCES:

(By Starfish and such)

ELECTRONS	5 Mev $>E>$ 500 Kev 3×10^8 ELECTRONS/cm^2-sec.	$E>$ 5 Mev 3×10^6 ELECTRONS/cm^2-sec.
NEUTRONS	$E>$ 25 Kev $\sim 10^{12}$ NEUTRONS/cm^2-sec.	$E>$ 1 Mev 10^{12}-10^{16} NEUTRONS/cm^2-sec.
GAMMA		10^7-10^9 ergs/gm (c)

simply because there are so many more of the former in space. It is known that the threshold for proton damage to semiconductors is on the order of 0.2 Mev. Much radiation in this region was created by the Starfish nuclear detonation as well as radiations in the higher-energy electron spectrum. Therefore, to properly simulate the proton radiation from this source, as well as from natural sources, a low-energy machine would be used in this typical experiment—the 0.1-1-Mev proton and electron accelerator.

At the same time, more than 90% of the total electron population at orbital altitudes have energies less than 4 Mev. Readings taken during November of 1962, for example, showed that at 600 km, more than a third of the electrons had energies from 2 to 3 Mev, half had energies less than 2 Mev, and only about 2% had energies greater than 4 Mev.

Because the energies cover such a wide range, the two machines operating simultaneously in the electron mode contribute a better sampling of the electron energy spectrum than one machine alone. Moreover, the two accelerators are needed to generate the many more electrons than protons required for a proper simulation of space conditions.

- **Scanning not needed**—Electron machines need large currents to irradiate large areas. The usual procedure is to scan an area with a beam moving back and forth. Orbiting satellites, though, see a uniform particulate field, not moving spots of radiation. "You can't properly simulate space radiation by irradiating only one point of a target at a time," Price affirmed. He suggested that the test might give entirely false impressions of the radiation of circuit boards, for instance, and many other electronic components.

The Goddard machines will irradiate one square foot of area without scanning. No other machines are known to have this capability.

For power to do the job, the 3-Mev electron accelerator will run on a beam current of 10 milliamperes, an amount more than 10 times greater than the commonly used beam currents of 400 microamperes maximum. Price noted that the 10-milliamperes beam is powerful enough to weld a steel plate or drill holes in it.

To irradiate a 1-sq.-ft. area, a beam will have to be de-focused and then clipped. Beam clipping will help maintain a uniform irradiation of the target, no one point getting more than twice the radiation of another point "in the worst case," Price said.

- **Cobalt-60 facility**—Another need is to determine the effects of ionizing radiation on the behavior of satellites as a whole as well as on their components. This requires irradiating an entire spacecraft at once, something that can not be done at the present time with accelerators.

A Cobalt-60 source putting out 1.2 Mev of gamma rays will be used to do the job even though there is no significant population of gamma rays in space. But since materials and components "usually don't care how they are ionized," said Price, the phenomenon can be simulated by gammas.

A cobalt-60 test, for example, might have discovered before *Telstar I* was launched that a surface ionization effect would occur on one of the transistors in the command circuit. This might have prevented the satellite's failure to perform four months later.

The cobalt-60 facility will be used to irradiate not only satellites, but also spacecraft subsystems of about a square foot in area and small targets such as materials and components. This versatility has brought up several knotty design problems because uniform radiation is wanted as well as full intensity no matter the size of the target. To conserve testing time, the experimenters would like to irradiate simultaneously objects in all three size categories.

Plans now call for putting small objects inside the gamma-ray source, and larger objects in an area around the outside of the source. To get uniform radiation of a satellite, "I think we will have to rotate it like a hot dog on a spit to avoid gamma-ray fall-off," said Price.

Goddard's new radiation environment facility is expected to round out the many chambers and apparatus the Center is using for full environmental testing of spacecraft. Space vacuums, temperatures and infrared are now simulated there to an acceptable extent. Particulate and ionizing radiations are the only gaps not adequately filled. This will be remedied when the three accelerators and the gamma-ray source go into operation in a year or two.

Experimenters will be greatly relieved when they are no longer forced to use the deterioration of solar cells as the sole measure of the deleterious effects of ionizing space radiation. ■

USNAVY
USNAVY
U S NAVY
A3X-0

Next for the Navy: the Poseidon missile

The Fleet Ballistic Missile System has never stopped growing since January 1, 1957 – the day the Navy first announced its plan to develop a ballistic missile to be launched from submerged submarines and chose Lockheed Missiles & Space Company to build it.

When the 1,200-nautical mile A1 Polaris *(at left in photo)* became operational in November, 1960, the 1,500-mile A2 Polaris *(center)* was in advanced flight test. And when the A2 first went on patrol, the 2,500-mile A3 Polaris *(right)* was well into its test program. The A3 has been in full production since midyear in 1964, and last September it joined the fleet.

Meanwhile, the Navy is preparing for the development of a still mightier missile – the Poseidon.

A significant point is this: The Poseidon will be launched from the same submarines built for the earlier Polaris missiles, thus taking advantage of the growth potential built into the original ship design.

The Fleet Ballistic Missile System program is an example without parallel in military history of planning for continuing growth and long-term cost-effectiveness. These 41 submarines, each armed with 16 missiles, will continue to be a mainstay of America's deterrent forces for many years to come.

Lockheed Missiles & Space Company, Sunnyvale, California: A Group Division of Lockheed Aircraft Corporation.

LOCKHEED

Computer Has Speed, Compactness

GE believes new all-solid-state A-212 unit offers highest processing speed available for its size; series aimed at in-flight uses

by Charles D. LaFond

THE FIRST OF A four-system, microelectronic, digital computer series, the A-212, has been demonstrated by the General Electric Co. throughout Washington's many military and NASA agencies. In addition, details of the other three newly designed systems were disclosed.

GE'S 18-LB. microelectronics computer is of typewriter size, and can perform more than 166,000 operations per sec. Future sets in series will up this to 500,000.

GENERAL SPECIFICATIONS FOR THE GE A-SERIES OF AEROSPACE DIGITAL COMPUTERS

	A-212	A-224	A-218	A-605
COMPUTATION RATE (includes instruction and operand access time)				
Add or Subtract	6 µs	6 µs	6 µs	6 µs
Multiply	11 µs	17 µs	14 µs	23 µs
Divide	12 µs	18 µs	15 µs	24 µs
Program Transfers	3 µs	3 µs	3 µs	3 µs
STANDARD MEMORY SIZE (words)	1,024	4,096	4,095	4,096
Expandable to (words)	8,192	8,192	260,000	260,000
WORD LENGTH (bits)				
Operand	12	24	18	36
Instruction	24	24	36	36
INSTRUCTIONS (Decoded Operations)	60	68	142	142
PHYSICAL CHARACTERISTICS (with standard memory and without power supplies)				
Volume (cu. in.)	750	925	1,200	1,350
Weight (lbs.)	18	23	28	36
Power (watts)	67	108	135	150

Employing semiconductor integrated circuits in more than 90% of the computer's electronic subsystems, the all-solid-state instrument features what GE developers believe to be the highest processing speed relative to unit size presently available.

The other computers in the A-series—whose designs are complete, but which have not yet been built—include the A-224, A-218, and A-605. The typewriter-size systems will vary in total weight/volume from 18 lbs. per 750 cu. in. for the A-212, to 36 lbs. per 1,350 cu. in. for the A-605. Power requirements range similarly from 67 to 150 watts.

The parallel organized devices employ the binary, two's complement number system and are designed for a variety of aerospace applications, including in-flight command and control, guidance and navigation, flight control, detection and penetration.

All units in the series developed by GE's Light Military Electronics Div., Utica, N.Y., are compatible with the existing larger commercial general-purpose computers, GE-625 and -635, and the military-type ground computers M-625 and M-605, also built by the firm.

- **General design details**—(Refer to the accompanying table.) The A-series features a basic memory cycle time of 3 µsec. and a standard memory stack of 1,024 words at 24 bits per word. Developers claim the A-212's speed can be increased to 1 µsec. and memory size directly increased to 4,096 and, with modifications, to 8,192 words.

The A-212 and A-224 employ two methods of address modification: register or register-then-indirect. Each employs one index register. The other two units in the series use four basic address-modification methods: Register;

Register-then-indirect; Indirect-then-register; and Indirect-then-tally. They both require eight index registers.

The basic fabricated subsystem is a flat-pack plug-in module carrying up to 18 semiconductor integrated-circuit elements. These are connected on larger boards, which may also carry thin-film-hybrid circuit cards (6 SIC flat packs and 3 cards).

Typical ancillary equipment to support the basic computers include an input-output console, flexiwriter, paper tape punch-reader, and (for the A-605) magnetic-tape, card reader-punch.

The A-series is designed for operation throughout the —55° to 125°C temperature range and subsystems have been subjected successfully to shock and vibration testing to prove suitability for aerospace applications.

- **A-series instructions**—Within the GE A-series computers, there exists an instruction compatibility—that is, the instruction set of a smaller system is a subset of a larger computer in the family. Thus, a program written for the A-212, smallest in the series, can be run on any of the other three computers.

In addition to the more standard instructions associated with larger general-purpose computers, the A-series is provided with instructions that can be used with particular advantage in real-time systems.

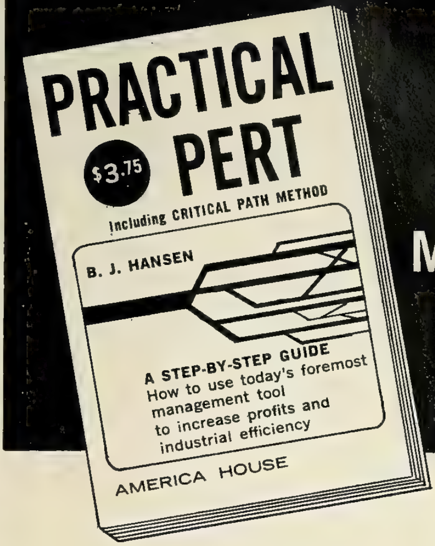
Any of the systems processors' arithmetic registers, said one GE spokesman, can be considered as accumulators to which quantities can be added, subtracted or combined logically.

The same is true of storage locations since the arithmetic sum of the quantities from a specified storage and register can be inserted into the storage location from which the addend was obtained. Another instruction would be needed to transfer to storage.

For shaft encoders and other devices requiring Gray code, a Gray-to-binary conversion instruction is used. For character handling (as might be required for alphanumeric displays), a binary-to-BCD instruction is provided.

Other special test instructions include "Compare Magnitude", "Comparative AND", "Comparative not AND", "Compare Masked", and "Compare with Limits". These, used with a "Repeat" instruction will cause the processor to run through the next appropriate instruction a specified number of times, as required. Thus, used with a "Compare with Limits" instruction, for example, the system might direct search of an applicable table in a track-while-scan problem.

Such an internal capability, GE feels, should make any of the A-series computers a powerful in-flight tool—particularly with the 3-μsec. memory-cycle time achievable. ■


PRACTICAL
$3.75
PERT
Including CRITICAL PATH METHOD
B. J. HANSEN
A STEP-BY-STEP GUIDE
How to use today's foremost management tool to increase profits and industrial efficiency
AMERICA HOUSE

FOR ALL LEVELS OF MANAGEMENT

2nd Big Printing!

$3.75

by B. J. HANSEN

(member of the original Polaris-PERT Team)

You get the complete **PERT** system and, for the first time, a **PERT** technique showing you how to predict and monitor profit on a continuing bi-weekly cycle.

Chapter XII, "Profit **PERT** and Incentives," brings you the Martin Company case history showing how the Titan III **PERT**-profit system works: In the words of Secretary of Defense Robert McNamara, "(Titan III) is probably the best managed contract we have, and it is the best managed almost entirely because of the tremendous incentive given to that contractor in the form of potential profit increases to hold his costs down."

PRACTICAL PERT tells how and when to meet contract obligations, how to keep programs on schedule, how to win highest incentive fees. **PERT,** developed for the nation's defense programs, can be applied to management operations to monitor profit as well as cost, time and performance in the fields of construction, chemical processing, manufacturing . . . and wherever complex systems are involved.

PRACTICAL PERT contents

I INTRODUCTION TO PERT
II THE ABC'S OF PERT
III PERT & TIME
IV HOW PERT PLANS
V HOW PERT CONTROLS
VI BUILDING PERT
VII WHAT IS NETWORKING
VIII REFINING THE NETWORK
IX MEASURING MANAGEMENT RISK
X PERT & COST
XI PERT COSTS & COMPUTERS
XII PROFIT PERT & INCENTIVES
XIII PERT DATA DISPLAY

AMERICA HOUSE
Dept. A
1001 Vermont Avenue, N.W., Washington, D.C. 20005

Send Me ☐ Copies of Practical Pert $3.75
.25c Handling
$4.00

☐ Check Enclosed ☐ Bill Me

Name ____ Job/Title ____

Address ____ City ____ ☐ HOME? ☐ BUSINESS?

Zip Code ____ State ____ Co. Name ____

AF Drafting Own Animal Satellites

Thirty-day feasibility test of module with chimpanzee to be made at year's end; study finds program requirement; Lockheed building hardware

by Heather M. David

THE AIR FORCE has begun laying groundwork for development of its own advanced, long-duration orbiting animal satellite.

The effort does not now constitute an approved flight program, but the first steps are being formulated in anticipation of the day that the need is recognized and the go-ahead is given. A contract has been let to Lockheed Missiles and Space Company to construct demonstration hardware suitable for the variety of missions Air Force doctors have in mind.

A 30-day feasibility test of the animal module, with a chimpanzee inside, will be made around the end of the year, Lt. Col. Al Swann, director of the life support activities of the Air Force Systems Command's Aerospace Medical Division, told M/R. He added, however, that the activity is not limited to chimpanzees; designs also are being worked out for separate subsystems for colonies of mice, various kinds of monkeys, and other small laboratory animals.

According to Swann the operation is a very preliminary step growing out of a study held within AMD last summer. This investigation determined that a biosatellite program was a definite requirement of the Air Force in advance of extended manned orbital missions. Orbital period would be from two months to a year.

Swann says the doctors also want to develop the technology so that they will be prepared in case something happens in the shorter-duration manned flights to make it necessary to stop and "go back and take a look at what happened." If some unforeseen physiological complication should impair the astronauts, it might be necessary to go back and do some basic, laboratory-type research with animals.

Swann estimated that with the completion of the current contract, a flight program could be ready in 1½-2 years, depending upon the level of effort. However, all of this hinges on determination of the Air Force's role in space.

- **Configuration**—Current studies are not pinning down the animal satellite concept to one particular booster or flight profile. For this reason, the 30-day test will not include vibration, noise or acceleration profiles. However, Swann said that the package would definitely not be suited to a piggyback flight, since these have been found to be extremely difficult for biological experiments.

Lockheed, under project director Stan Hall, is now firming up design of the chimpanzee demonstration model and choosing subsystem contractors. Although flight hardware will not be used, Swann said, the Air Force is pressing for advances in the state of the art in life support and environmental control systems.

The Air Force has required that the design include a two-gas oxygen/nitrogen atmosphere at sea-level pressure. Although recommendations for subsystems such as power supply will evolve, complete systems will not necessarily be designed and operated in the 30-day experiment.

The test will be conducted in an altitude chamber to validate the environmental control system. However, the biggest problem of designing such a long-term system is not environment but the waste management system, Swan indicated.

Specific experiments for a AF biosatellite are not now being drawn up, although a number of ideas have been discussed to make sure that the module design will fit all the requirements. Experiments for the chimpanzee probably would include cardiovascular studies, examination of muscle and mineral states following weightlessness, central nervous system studies and performance tests.

Mice colonies would be suitable for genetic studies and evaluation of the effects of weightlessness upon growth. Experiments on synergetic effects of weightlessness and radiation also would be of interest. Swann further said that although the prime payload of any of the various possible capsules would be based upon whole animal studies, cellular and tissue cultures probably would be carried along if space permitted.

In-house studies are being conducted by AMD in support of the Lockheed work. These are concerned primarily with establishing laboratory control information on routines of performance, confinement, feeding and the like so that the 30-day test may be compared. These are being carried out at the Aerospace Medical Research Laboratory at Holloman AFB, N.M., which has a long history of working with primates for spaceflight research.

- **Other proposals**—AMD has received a number of unsolicited proposals for animal satellite research, although the Lockheed study is the only funded version at present. Lockheed also carried out shorter-duration tests, in the old Air Force *BOSS* and *Bravo* projects, discontinued several years ago.

The climate for approval of an Air Force program is improving as prospects for manned flight ripen. Scientific opinion, even within the Air Force, is somewhat split over the validity of animals as precursors to man in space. But the outlook is better than it was a few years ago when the *Discoverer* monkey capsule was dropped from the active list, and *BOSS* from the proposed flight program list.

Opposition to the animal program exists among some of manned spaceflight's stoutest supporters, on the basis that if an animal should unexpectedly die—as in laboratories they do for no apparent reason—it would damage the manned program's chances. However, the feeling is growing—partly spurred by Soviet cautiousness regarding long-term spaceflight effects—that an animal program will be approved for preliminary long duration research.

- **Cooperation**—It's reported that the Air Force program has been carefully coordinated with NASA efforts and is expected to be useful to both agencies. The working concept is that it would serve as a "follow-on" to the knowledge gained in NASA's *Biosatellite* program. Longest mission in the NASA-approved program is 30 days. ■

Gravity or Zero Gravity. Under state-of-the-art technology it's feasible to provide effective control subsystems for orbiting vehicles, which spin to produce gravity. Rigidly joined or cable-connected modules can be controlled by present techniques. Sperry has recently evaluated control methods to establish this. □ Zero gravity controls? Sperry has made intensive in-house studies of control needs for vehicles ranging from those with artificial gravity capability to those designed for weightless operation, with minimum control requirements... for scientific experiments ... and for military missions, from reaction jet to hybrid systems using momentum-exchange concepts. Leader in aerospace control and stabilization, Sperry offers reliable performance for these challenges in space. **GENERAL OFFICES, Great Neck, N.Y.**

SPERRY
DIVISIONS OF
SPERRY RAND
CORPORATION

Circle No. 12 on Subscriber Service Card

"Follow the man from Schiller Park. He's showing a new Portable Dynograph® Recorder at IEEE. It's priced under $1,300. You ought to see it!"

Visit Booth 3407. Learn how you can save $500 or more on your next 2-channel direct-writing recorder. It's available with ink curvilinear, ink rectilinear or heat rectilinear recording media. It weighs less than 40 pounds, provides millivolt sensitivity, extreme ruggedness and maximum operator convenience. If you can't see it at IEEE contact your local Offner Division Sales Engineering Representative or write for Data File 718.

Beckman® INSTRUMENTS, INC.

OFFNER DIVISION

SCHILLER PARK, ILLINOIS • 60176

INTERNATIONAL SUBSIDIARIES: GENEVA, SWITZERLAND; MUNICH, GERMANY; GLENROTHES, SCOTLAND; PARIS, FRANCE; TOKYO, JAPAN; CAPETOWN, SOUTH AFRICA

Circle No. 13 on Subscriber Service Card

Crystal Valve Feasible for Color TV

RADC expert says light valves with resolution of 500 TV lines appear easily obtainable; research program needed for military displays

by Rex Pay

SANTA MONICA, CALIF.—Use of a solid-state light valve for large military full-color displays or for commercial projection television is definitely feasible and quite promising. The valve should be a practical large-screen projection device within two years.

Edward J. Calucci of the Air Force's Rome Air Development Center (RADC) put forward these views when describing work on crystalline light valves at the Center. Speaking at the Fifth National Symposium of the Society for Information Display, he said that a resolution of 500 TV lines per inch could probably be readily obtained with these devices, but that the 1,000 lines per inch required for military applications will call for more sophisticated techniques.

He said a materials research program is required to develop new and improved electro-optical crystals.

Development of a crystalline light valve was undertaken by the projection display section at RADC to see if these devices could meet the military requirement for large-scale full-color display devices that are reliable and have real-time capabilities. High brightness, high resolution, high information rates and multiple input capability were also required.

● **Present limitations**—Present film systems are limited in their presentation of real-time information because of their processing time. Television systems are generally inadequate for group displays, because of their size, and lack sufficient image brightness for large-size optical projection.

Study of the electro-optical effect for light modulation started at RADC in 1961. RADC is currently evaluating proposals from a number of contractors for further work in this area.

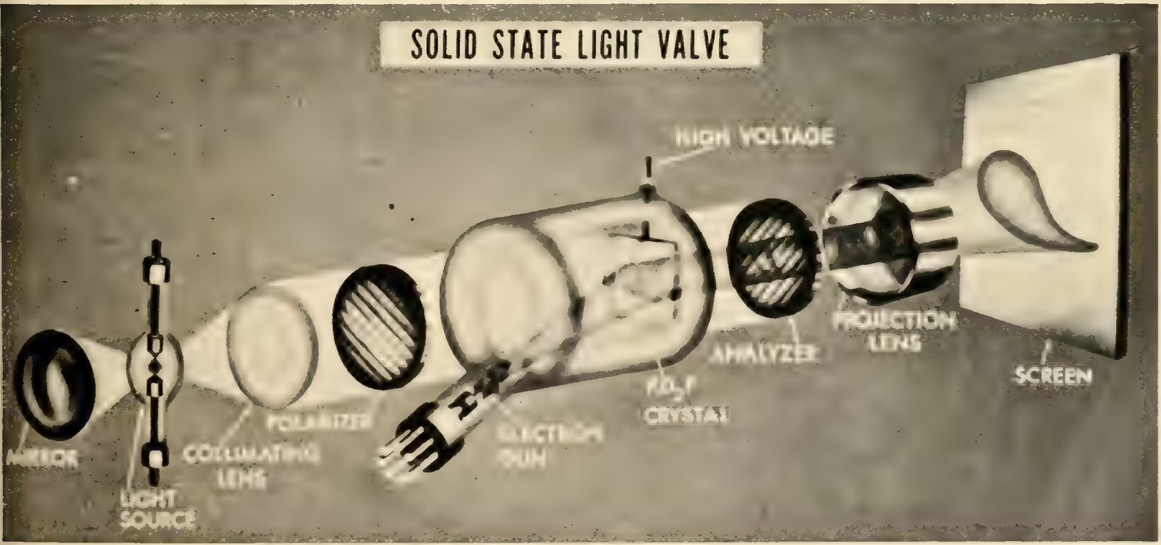
A working system has been built in-house at RADC. This has shown a resolution of 250 TV lines per inch and a contrast ratio of 150:1. The resolution was thought to be limited by features of the equipment that could be readily improved.

Calucci said that the work at RADC has been with tetragonal crystals of KD$_2$P, ammonium dihydrogen phosphate (ADP), and potassium dihydrogen phosphate (KDP). Cubic crystals of cuprous oxide and zinc sulphide would be more suitable for this application because their optical axis is omni-directional, but the present crystal sizes and optical qualities available are unsatisfactory.

All these crystals show the longitudinal electro-optical effect, that is, change in optical properties of the crystal occurs when an electric field is applied parallel to the incident optical wave. The longitudinal effect is of interest because the optical properties within the crystal must be changed in the direction of the incident light on a point-by-point basis to achieve an optical image.

To provide point-by-point control of the electric field across the crystal, thin-film transparent electrodes are deposited on its faces and potential patterns are developed by use of an electron beam.

● **System details**—The basic system investigated at RADC consisted of a 100-watt mercury arc lamp, a three-inch collimating lens, a two-inch plastic polarizer, the electron-beam and crystal



assembly, and a Glan-Thomson prism analyzer.

When plane-polarized light passes through an electro-optical crystal in an electric field, the polarization vector is rotated. Initially, with no voltage applied to the crystal, no light is transmitted through the light valve because the polarizer and analyzer are positioned orthoganally.

Application of an electric field causes the crystal to become biaxial. The incident-polarized light then resolves into two ray components: the ordinary ray and the extraordinary ray. Because the indices of refraction differ for the two ray paths, the effect is to produce elliptical polarization. The analyzer then permits only one plane component to pass.

In fact, the amount of light that emerges from the analyzer depends on the voltage applied to the crystal. In this way, the applied voltage modulates the intensity of the light beam from the projector.

● **How it functions**—When a stationary electron beam falls on the crystal electrode, a spot of light is transmitted. Deflecting the beam causes the spot to traverse the screen onto which the light is projected. Modulating the beam causes the light intensity to change.

White on black or black on white images can be readily produced. Three-color mixing can be obtained by combining the outputs of three separate solid-state light valves. Alternatively, the analyzer in one light valve could be replaced with an optical rotator and variable polarizing filter. Various colors can be obtained by controlling the polarization angle.

Use of a KDP crystal or an ADP crystal produced images of reduced brightness. Comparative tests showed that KD_2P definitely exhibited increased optical sensitivity. Continual operation of the light valve led to slight discoloration and deterioration of the crystal. This was attributed to the high vapor pressure of crystals of this type, and to their instability under an electron beam. Coatings applied to the crystal surface should remedy this situation. North American Aviation Inc.'s Autonetics Div. has developed techniques for sealing the crystal and for incorporating a Vacion pump in a sealed-off device.

Calucci suggests that a materials research program is required to grow new crystals, particularly the KDP isomorphs. The single crystals must be strain free, uniform in resistance, free of inclusions and stable in a vacuum. Studies on contract and at RADC will be directed toward improved resolution, higher light intensities, cooling techniques, and design of a full-scale system. ■

space systems

NASA Still Considering Mars Capsule for 1969

Los Angeles—NASA has not ruled out the possibility that a small capsule might be deployed into the Martian atmosphere in 1969.

"This would be most desirable," said Edgar M. Cortright, NASA Deputy Associate Administrator for Space Sciences and Applications, in a recent interview here. He added that the probe would be used to make physical measurements of atmospheric characteristics and would not be a life-detection experiment.

Cortright pointed out that a set of scientific experiments would also be needed for the spacecraft bus in the hoped-for 1969 *Voyager* test flight to Mars. As the on-board scientific instruments for spacecraft are the items that call for the longest lead times, these must be selected soon: "this year or early next year," said Cortright.

The main advantage of the 1969 mission would be the opportunity to exercise the *Voyager* bus. NASA would also like to exercise a retro-rocket system for putting the bus into orbit around Mars, said Cortright, but this has lower priority.

At present, the contractual arrangement that can be expected for the *Voyager* retro-rocket has not been defined. NASA has asked that studies should make the interface between the retro package and the main bus as simple as possible. This will allow the rocket development to be carried out by a subcontractor to the prime spacecraft contractor, or by an associate contractor, said Cortright.

● **The 1971 mission**—Discussing the 1971 mission, Cortright said that there is a good chance that the full *Voyager* capsule capability will not be used in this mission, because a full complement of suitable sterilized payload equipment may not be available. He said that use of multiple small and medium size capsules has not been ruled out for this mission. "We are going to have an option of one or multiple capsules in 1971," he suggested.

He said ground-based astronomical measurements this spring are expected to improve knowledge of the density of the Martian atmosphere to within an accuracy of 25%, and so refine the design of entry probes. He added that a somewhat similar measurement accuracy is now expected for the *Mariner* Mars radio occultation experiment in July.

Cortright said that detection of ice crystals in the Venus atmosphere by the balloon-borne infrared spectrometer experiment of Professor John Strong of Johns Hopkins University, could have an important bearing on the course of space exploration. Cortright said he had not yet been able to study Strong's experiment and did not know how to rationalize the discrepancy between the new results and the high temperatures registered by the infrared radiometer of *Mariner II*. "If Strong were right and you had a modest temperature at the surface, there would be the possibility of life on Venus," said Cortright.

● **New capsule required**—He said the aim of the *Voyager* design was to build a spacecraft with the capacity to go to Mars and then be in the position to back-off from some of the design limits to handle the Venus mission. However, a completely different capsule would be needed for entry into the Venus atmosphere.

A buoyant capsule that could be injected into the Venus atmosphere from an orbiting *Voyager* has been studied by Goodyear Aerospace Corp. An instrument package would be carried by an expandable drag body, or Ballute. This would be capable of withstanding entry into the Venus atmsophere and also of floating at an altitude of about 70 km for an extended time.

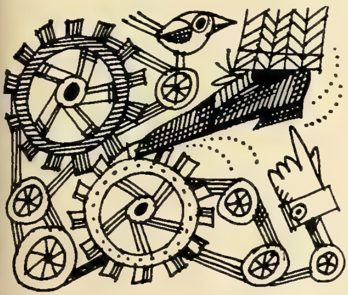
The aim would be to float the instruments at an altitude where the temperature is less than 160°F, so avoiding the need for refrigeration equipment.

Describing the study to the AIAA meeting, F. R. Gross said that lack of knowledge of the Venus atmosphere results in a wide range of published density and temperature values. He said that a Venus surface temperature reading of about 620°F obtained by Earth-based observations had been confirmed by *Mariner II* microwave readings. But temperatures predicted for 100 km altitude vary from a minimum of —170° to +200°F. ■

INSPIRATIONAL THOUGHTS FOR THE TECHNICALLY INCLINED

THE RELUCTANT MOTOR THAT NEEDED ITS KICKS

The first part of this story deals with a reluctant stepper with big dreams. Like most of his kind, he was happiest standing still and required a swift kick now and then to get him moving. When he did work, his major attributes included his ability to move in smaller steps, at faster rates and with less effort than most of his contemporaries. The problem was to find him a job compatible with his ability.



Sometimes a man happens to be at the right place at the right time, and this is what happened to our little friend. Digital computers need a translator to turn their binary chatter into everyday talk. The place, the time and the dream coincided. Our hero was built like a variable-reluctance machine, but in the right job he overcame his natural shyness and became downright enthusiastic. So were the engineers who worked with him.

The qualifications of this stepper and his permanent magnet cousins are spelled out below. And let us add these valuable remarks. First, our variable reluctance motors are non-resonant, have response rates as high as 1000 pulses per second and stepping angles of 15°. Secondly, the permanent magnet types are so positive about their position that synchronous operation is possible. More than that, they stay where they belong without mechanical detents even during vibration.

TYPICAL STEPPER MOTOR CHARACTERISTICS

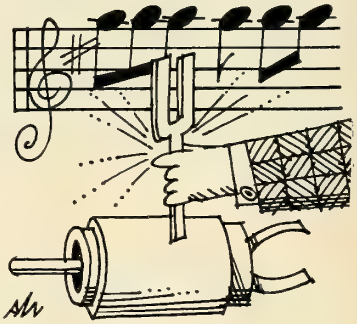
	VARIABLE RELUCTANCE		PERMANENT MAGNET	
SIZE	**8**	**11**	**8**	**11**
Stepping Rate-Pulse/Sec.	1000	700	300	200
Stepping Angle	15°	15°	90°	90°
Holding Torque	0.5 in oz	1.1 in oz	0.65 in oz	1.8 in oz
Power Input	8.5 W/O	7.8 W/O	5.25 W/O	7.0 W/O
Part Number	CM00192750	CR00192750	CM40191007	CR00191750

We also supply the driver electronics

JOHNNY-ONE-NOTE

A relative of this stepper is musically inclined, and like him has a personality trait which while peculiar has definite value. Cousin Johnny shows a singleminded tendency to run at one constant speed providing he is excited by a specific "note." Most frequently the note has a frequency of 400 cps.

The synchronous motors we make do their job better than most. They provide the right combination of high torque and high efficiency in very small packages. They are absolutely requisite for applications in which their hunting and jittering contemporaries can't make the grade. Here's the data that fits this maestro of miniscule motors.



SIZE	**8**	**11**	**15**
Voltage	26V	115V	115V
Frequency/Phase	400 cps	400 cps	400 cps
Speed	8000 rpm	8000 rpm	8000 rpm
Pull Out Torque	0.27 in oz	0.45 in oz	1.3 in oz
Pull In Torque	0.20 in oz	0.34 in oz	1.25 in oz
Stall Torque	0.20 in oz	0.34 in oz	2.0 in oz
Power (at P. O.)	3.4 watts	6.0 watts	8.2 watts
EFF (at P. O.)	24%	50%	50%
Part Number	CMO 0174 002*	CRO 0174 003	CTO 0174 003

*Size 8 unit for 115 volt operation available.

If you need more answers, we've put all this data in a brand new brochure we'd like to send you. Please let us know where.

KEARFOTT DIVISION

GENERAL PRECISION INC.

AEROSPACE GROUP
Little Falls, New Jersey

Circle No. 14 on Subscriber Service Card

What does it take to hand-carry the American flag to the moon?

Cameras, batteries, chargers, a life support system, fuel cells, instrumentation, electronic test systems, communications, computers, decoders, navigation, guidance, tracking beacons, antennas, heat shields, parachutes, radar, rocket engines, propellants, the Manned Spacecraft Center, a launching platform, nuclear gauges, fuel tanks, sensors, the Edwards High Thrust Test Area, launch vehicles, electrical lines, a launch escape system, adapters, an optical communications system, Cape Kennedy, oxidizer tanks, pressurization systems, multicolored nylon, instant food, container packets, tooling, ground support, structures, handling and transport equipment, the George C. Marshall Space Flight Center, a blockhouse, administration, columbium metal, warehouses, security, an electronic metronome, the White Sands Missile Range, expulsion tanks, pitch controls, engines, a Lunar Excursion Module, recovery equipment, power conversion units, the Michoud Operations Plant, environmental control, valves, oxygen, diodes, water, plastics, forgings, deceleration rockets, mission simulators, engineering drawings, the Atlantic Missile Range, a test pendulum, crew couches, the Santa Susana Field Laboratory, liquid gauging equipment, honeycomb core material, aluminum alloy, hydraulic servo actuators, design reviews, the Mississippi Test Facility, cryostats, wash pads, ventilation fans, research, structural ribs, metal foil, transportation, test chambers, hydrogen, carbon steel, cement, turbopumps, the Nevada Field Laboratory, injectors, gas generators, stainless steel, O-rings, high pressure ducting, a steam generator, gimbals, microelectronics, flight suits, scientific seminars, fins, anti-slosh baffles, fairings, destruct packages, clamps, plumbing, stringers, corrugated skins, steam diffusers, a shaker table, blast shields, wind tunnels, gyros, telemetry, flight plans,

and three Astronauts
seven-and-a-half-million pounds of thrust
20,000 American companies
and the Apollo spacecraft built for NASA
by North American Aviation

Atomics International, Autonetics, Columbus, Los Angeles, Rocketdyne, Science Center, Space & Information Systems

The Industry Week

Mergers and Acquisitions

Anelex Corp. of Boston has acquired Advanced Space Age Products, Inc., Alexandria, Va., and will operate the company as an autonomous subsidiary. Anelex produces high-speed printout systems for the computer industry; ASAP specializes in electrical and mechanical products manufacturing. ASAP's present management and work force is to be retained. . . . *Allegheny Ludlum Corp., Pittsburgh, has acquired Special Metals, Inc., New Hartford, N.Y., which will operate as an independent subsidiary. SM develops and produces high-purity metals through vacuum induction melting and vacuum arc melting. This new capability will be added to AL's research and production facilities in preparation for AL's intended move into the aerospace and deep submergence fields.* . . . Bourns, Inc., Riverside, Calif., has purchased Chicago Aerial Industries, Barrington, Ill. Itek Corp. had planned to acquire CAI assets (M/R, March 1, p. 39), but the deal was called off by CAI when the Bourns offer was made (M/R, March 15, p. 37). . . . *The Benson-Lehner Corp., a Van Nuys, Calif., subsidiary of United Gas Corp., has purchased for an undisclosed amount the Telecomputing product line of the Data Instruments Div. of the Whittaker Corp. The manufacturing and engineering operations of the Data Instruments Div. will be moved to the Van Nuys facility of B-H to expand its manufacturing and engineering capabilities.* . . . Walter Kidde & Co., Inc., Bellville, N.J., has agreed to purchase Weber Aircraft Corp. and Weber Showcase & Fixture Co., Inc., of Los Angeles. Weber makes temperature-controlled display equipment as well as aircraft and space vehicle pressure-activated equipment. . . . *Acton Laboratories, Inc., Acton Mass., a subsidiary of Bowmar Instruments Corp. has purchased the Rayspan spectrum analyzer business of Raytheon Co.'s Components Div.*

New Activities

Radiation, Inc., Melbourne, Fla., and Union Carbide subsidiary, Data Systems, Inc., of Detroit have signed an agreement under which the Control Systems Div. of RI and Data Systems, Inc., will pursue marketing opportunities in the automation of chemical processing plants. . . . *Lockheed Missiles & Space Co. has formed a Special Product Services organization in the San Francisco Bay Area to seek out additional markets for the specialized skills and facilities of aerospace technology and to assist in maintaining a steady production pace. Among the products and services that Special Products Services will exploit are: lightweight, flexible electronic circuitry; beryllium fabrication and machining; manufacturing research and technology; and measurement and testing services that have been developed for in-house programs.* . . . Industry Week last week in a New Activities item on Avco Corp.'s Research and Advanced Development Div. erred in the identity of three Avco Officials. E. D. Kenna is an Avco vice president and the general manager of the Research and Advanced Development Div.; not the president of Avco. Named to the newly created R&AD Div. post of vice president of space systems was Dr. M. C. Adams; not Dr. J. A. Kyger as reported here last week. Kyger, who has been vice president and assistant general manager for the R&AD Div. will now serve in the dual capacity of deputy general manager to Kenna and assistant general manager for operations and support. The president of Avco is James R. Kerr.

In the Courts

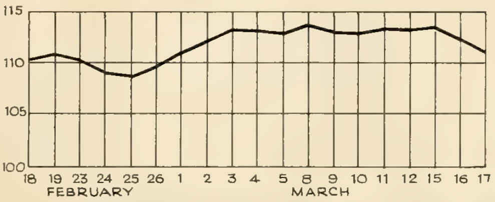
The Government has brought a $551,344 damage suit against Systron-Donner Corp. in a California Federal Court. The suit charges that the Concord, Calif., firm knowingly overestimated labor and materials costs associated with 415 ignition programmers it supplied Lockheed Missiles & Space Co. under a Polaris missile subcontract. The Government claims that "false and fraudulent" price proposals made by S-D in the course of the cost-plus-fixed-fee contract cost $260,670 in overcharges. It is seeking double that amount under provisions of a false claim statute. An additional $40,000 is sought as repayment for alleged double-billing on the part of S-D.

New Facilities

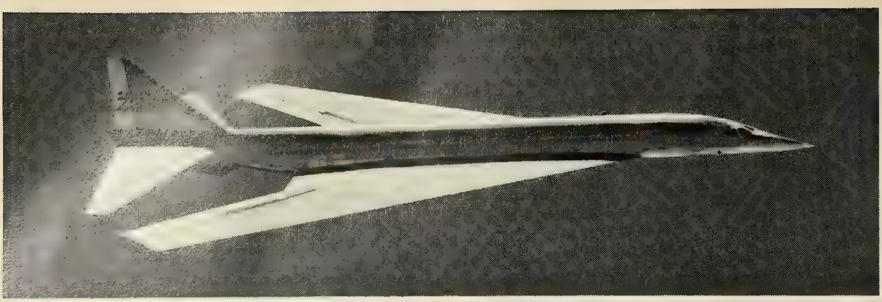
General Dynamics/Convair, San Diego, Calif., has completed a $6-million test facility to be used by NASA in rehearsing *Atlas-Centaur-Surveyor* vehicles for lunar missions. Called the Combined Systems Test Stand, the facility is the first built to accommodate all stages of a space vehicle. The *Centaur-Surveyor* will fit into an 89-ft. tower in a vertical position, and the launch vehicle will be supported horizontally in a 100-ft.-long bay.

Missile/Space Stock Index

The Missile/Space Stock Index ebbed slightly after being stimulated by surges in individual stocks with the award of several multi-million-dollar contracts and the release of company annual reports that showed in several instances higher profits despite lower sales during the year. United Aircraft, for example, had a 4% drop in sales, but experienced a thirty-six percent increase in earnings. This trend has been reflected in per-share earnings, attracting stock investment.



STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH



tomorrow and today,
BOEING
for
opportunity

ENGINEERS ARE NEEDED in the following assignments to carry on the nearly half century Boeing tradition of designing tomorrow's airplanes today for military and commercial use. These requirements are in Boeing Airplane Divisions with locations at Wichita, Kansas and Renton, Washington.

FLIGHT CONTROL SYSTEMS — Establish design criteria and specifications for flight control systems, subsystems and components; selection of components; and monitoring of flight test.

CONTROL DYNAMICS — Servo control analysis to develop automatic terrain-following concepts, load-alleviating stability augmentation systems and automatic flight control systems. Experience in analog computer programming and familiarity with digital computer techniques.

AERODYNAMICS—Perform analysis of aerodynamic characteristics effected by airplane control systems and stability augmentation systems. Experience in systems analysis and working knowledge of analog computers.

STRUCTURAL DYNAMICS—Analysis of complex structure virbration, airframe loads and response, and application of probability theory to structural design criteria.

LOADS ANALYSIS — Perform aeroelastic loads analysis, coordinate loads testing and establish requirements for extensive design loads investigations.

STRESS ANALYSIS—Perform research of load-paths and strength characteristics of aircraft structure. Perform strength checks and formal stress analysis. Establish programs and document analysis data.

HYDRAULIC SYSTEMS—Analysis, testing and design of hydraulic systems. Experience with system pumping, control components, and heat transfer of high pressure systems (knowledge of current techniques used in hydraulic servo valves for powered flight controls).

ENVIRONMENTAL CONTROL — Heat transfer analysis with application to air cycle conditioning of jet aircraft. Emphasis upon avionic equipment conditioning to develop new environmental conditioning concepts.

ANTENNA SYSTEMS — Design, performance, evaluation, and analysis of radome, antenna, and RF transmission systems. Experience in antenna, radome, or wave propagation.

NAVIGATION AND GUIDANCE SYSTEMS — Analysis of electromechanical systems anc derivation of system transfer functions tc quantitatively predict system performance Experience in feedback control systems

OTHER POSITIONS AVAILABLE IN: • FLIGHT TEST OPERATIONS • FLIGHT TEST INSTRUMENTATION • FLIGHT TEST DATA PROCESSING • ELECTRONIC COUNTERMEASURES • HUMAN FACTORS • TECHNICAL PUBLICATIONS • WEIGHTS • FATIGUE ANALYSIS • RADAR TECHNOLOGY • WEAPONS DELIVERY SYSTEMS • ELECTRICAL SYSTEMS • OPERATIONS RESEARCH

All positions require a B. S. or advanced degree in engineering, physics or mathematics. You are invited to send your resumè or letter indicating your specific area of interest to either:

Mr. Tom Sheppard, Dept. BAX
Boeing Airplane Division
P. O. Box 707
Renton, Washington 98055

☐

Mr. Gerald Caywood, Dept. BAX
Boeing Airplane Division
4300 E. MacArthur Road
Wichita, Kansas 67210

BOEING
AIRPLANE DIVISIONS
RENTON, WASHINGTON ■ WICHITA, KANSAS

An Equal Opportunity Employer

contracts and procurements

AWARDS

AIR FORCE

$3,905,500—**General Telephone & Electronics Corp.,** Sylvania Electric Products, Inc., New York City, to provide technical publications for the ground electronic systems of *Minuteman.*

$3,200,000—**TRW Space Technology Laboratories, Inc.,** Redondo Beach, Calif., for continued work on unspecified space programs.

$2,340,900—**The Boeing Co.,** Seattle, for work on *Minuteman* missile system.

$2,086,632—**Ford Motor Co.,** Philco Corp., Philadelphia, for production of radio equipment.

$1,196,120—**General Dynamics Corp.,** San Diego, for spare parts for *Atlas-Agena* boosters.

$651,440—**Aerojet-General Corp.,** Sacramento, Calif., for analytical overhaul of one *Titan II* engine system.

$246,632—**United Aircraft Corp.,** Research Laboratories, East Hartford, Conn., for demonstration of performance characteristics of a cryogenic tripropellant system.

$99,997—**Eitel-McCoullough,** San Carlos, Calif., for 12-month research for design criteria for super power beam type stitch tube.

$89,730—**Syracuse University,** Syracuse, N.Y., for 12-month ground antenna characteristics study.

$84,750—**Lockheed Aircraft Corp.,** Lockheed Georgia Co., Marietta, Ga., for lightweight reactor shielding material study.

$81,500—**Westinghouse Electric Corp.,** Baltimore, for 10-month tactical orbital programmer study.

$75,500—**Avco Corp.,** Tulsa Div., Tulsa, Okla., to supply 20 radiation dosimeters for use on unmanned satellites.

$69,144—**TRW Space Technology Laboratories, Inc.,** Redondo Beach, Calif., for continuation of research on properties of accelerated plasmas.

$50,000—**Perkin-Elmer Corp.,** Norwalk, Conn., for eight-month optical propagation study.

ARMY

$3,552,518—**General Dynamics Corp.,** Pomona, Calif., for feasibility validation program of the *Mauler* weapons system.

$3,336,000—**Honeywell Inc.,** St. Petersburg, Fla., for classified electronics equipment.

$1,492,660—**Ford Motor Co.,** Philco Corp., Newport Beach, Calif., for development and production of the *Chaparral* air defense missile.

$1,460,000—**TRW Space Technology Laboratories, Inc.,** Redondo Beach, Calif., for classified research and development.

$1,237,572—**General Dynamics Corp.,** Pomona, Calif., for engineering services on *Redeye* missile.

$903,000—**Radio Corp. of America,** Missile & Surface Radar Div., Moorestown, N.J., contract increase for the *AADS-70* program.

$450,000—**Hughes Aircraft Co.,** Fullerton, Calif., for trade-off studies in *AADS-70's* program system engineering and design.

$276,856—**Greenhut Construction Co., Inc.,** Pensacola, Fla., for an addition to a test lab and modifying test stand facilities at NASA's Marshall Space Flight Center.

$224,280—**Sperry Rand Corp.,** Salt Lake City, for research and development engineering study of the *Sergeant* missile system.

$166,124—**Aerojet-General Corp.,** Astrionics Div., Azusa, Calif., for design study and development of a prototype infrared measuring system for calibration support of surveillance and missile guidance systems.

$99,209—**Bell Aerosystems Co.,** Buffalo, N.Y., for a feasibility study for using metal bladders on the *Lance* missile.

$86,355—**Vitro Corp. of America,** Vitro Electronics Div., Silver Spring, Md., for telemetry receivers.

$79,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., for high performance thin film microcircuits.

$57,060—**Northrop Corp.,** Anaheim, Calif., for *Hawk* wing assemblies.

$34,950—**Pure-Aire Corp. of America,** Van Nuys, Calif., to design, fabricate and install a portable clean room at NASA's Merritt Island Launch Area.

NAVY

$56,973,390—**Newport News Shipbuilding & Drydock Co.,** Newport News, Va., for two nuclear powered submarines.

$54,754,390—**General Dynamics Corp.,** Groton, Conn., for two nuclear powered submarines.

$2,793,380—**Aerojet-General Corp.,** Von Karmon Center, Azusa, Calif., for engineering services and materials for Mk 46 Mod O torpedo.

$1,480,832—**Lockheed Aircraft Corp.,** Burbank, Calif., for an oceanographic research study.

$1,414,097—**Clevite Corp.,** Clevite Ordnance Div., Cleveland, for research and development on back-up guidance and homing control system for use with Mk 48 wire guided ASW torpedo system.

$1,150,000—**Sperry Rand Corp.,** Ford Instrument Co., Long Island, N.Y., for engineering services for modification kits for *Terrier* and *Tartar* computers and ancillary equipment.

$1,024,693—**Technical Appliance Corp.,** Sherburne, N.Y., for research on antenna systems.

$462,000—**ITT Federal Laboratories,** Ft. Wayne, Ind., exercise of option for *Tartar* detecting device for *Terrier* missile.

$650,000—**Thiokol Chemical Corp.,** Reaction Motors Div., Denville, N.J., for research for feasibility demonstration of an advanced integrated packaged liquid engine.

$415,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., increase in contract for the AN/ARC-104 program.

$414,987—**Texaco Experiment, Inc.,** Richmond, Va., for increased research and development on low-volume ramjet development program.

$389,524—**General Dynamics Corp.,** Pomona Div., Calif., for facilities in support of standard missile program.

$300,000—**General Dynamics Corp.,** Pomona Div., Pomona, Calif., for technical service for *Terrier* and *Tartar* missiles.

$295,363—**Westinghouse Electric Corp.,** Sunnyvale, Calif., for research and development to demonstrate compatibility of interfaces in advanced launcher design.

$275,000—**Western Electric Co.,** New York City, for development of design improvement changes in *Terrier/Tartar* weapon direction equipment.

$205,592—**Westinghouse Electric Corp.,** Underseas Div., Baltimore, for continued development of Mk 45 torpedo.

$190,000—**Mesa Scientific Corp.,** Inglewood, Calif., for development support of Communications Automatic Processing Equipment part of Southern Cross.

$150,000—**Texas Instruments, Inc.,** Dallas, for exploratory development directed toward an investigation of background discrimination techniques for air-to-surface missiles.

$95,000—**Aerojet-General Corp.,** Sacramento, Calif., for services for *Tartar, Sparrow III* and *Regulus* rocket-type propulsion assemblies.

$74,919—**Dynetics, Inc.,** Mountain Lakes, N.J., for research and development on means of controlling particle trajectories in two phase flow to permit design of more efficient plug nozzles.

$72,576—**Catalyst Research Co.,** Baltimore, for *Sidewinder* thermal batteries fuze.

NASA

$41,000,000—**Douglas Aircraft Co.,** Santa Monica, Calif., for continued work on *S-IVB* stage.

$10,000,000—**Douglas Aircraft Co.,** Santa Monica, Calif., for continued work on *Saturn S-IV* stage.

$1,366,511—**Santa Fe Engineers, Inc.,** Lancaster, Calif., for the construction of a high temperature heat load testing facility at Flight Research Center.

$1,059,000—**Aerojet-General Corp.,** Aetron Div., Covina, Calif., for installation of equipment on a *Saturn V* second stage test stand at Mississippi Test Operations.

$526,926—**Cornell Aeronautical Laboratory,** Buffalo, for research related to application of shock tube techniques to the study of rocket-propelled vehicle base thermal environment.

$183,000—**Beckman Instruments, Inc.,** Fullerton, Calif., for safety instrumentation packages for *Apollo* space simulation chamber.

$97,873—**Northrop Corp.,** Norair Div., Hawthorne, Calif., for theoretical study of the aerodynamic characteristics of lifting body entry vehicles.

$49,796—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for design of a hand-held space sextant for use in *Gemini* space vehicles.

$41,351—**Lockheed Missiles & Space Co.,** Sunnyvale, Calif., for *Fire II* mission support.

INDUSTRY

$1,000,000—**Lear Siegler, Inc.,** Santa Monica, Calif., from the **Gyrodyne Co. of America, Inc.,** Washington, D.C., for avionic equipment for the QH-50 C drone helicopter, part of project DASH (Destroyer Anti-Submarine Helicopter) weapon system.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Nike X Project Office
Army Materiel Command
Redstone Arsenal, Alabama

Negotiations are being conducted with Western Electric Co. for additional effort in connection with the Nike-X development program. This synopsis is made to publicize subcontract opportunities. Make inquiries directly to Western Electric.

U.S. Army Missile Command
Redstone Arsenal, Alabama

Selected source procurement with Westinghouse Electric Corp., Research Laboratories, for nine months study of high energy coaxial laser pumps is being negotiated. Small business firms or others interested in subcontracting should contact Westinghouse directly.

National Aeronautics and Space Administration
Manned Spacecraft Center
General Research Procurement Branch
2101 Webster-Seabrook Road
Houston, Texas 77058

MSC has issued RFP BG751-28-5-624P for a lunar survey probe. The study will deal with a system study to deliver specific payloads from lunar orbit to immediate vicinity of the lunar surface and to relay information from the landed payloads to an orbiting *Apollo* spacecraft. RFP due date is April 12, 1965.

National Aeronautics and Space Administration
Manned Spacecraft Center
General Research Procurement Branch
2101 Webster-Seabrook Road
Houston, Texas 77058

MSC is seeking the development of a mathematical analysis for predicting the dynamic behavior of the Apollo Command Module during Earth landing. RFP BG51-41-5-635P due date is April 6, 1965.

Negotiation Branch 1
Systems Contracts Division A
Procurement and Production Directorate
U.S. Army Missile Command
Redstone Arsenal, Alabama

Negotiations are being conducted with Avco-Everett Research Laboratory for continuation of work in research in re-entry physics. RFP not available, however, it is suggested that small business firms or others interested in subcontracting opportunities in connection with this procurement make direct contact with Avco-Everett.

products and processes

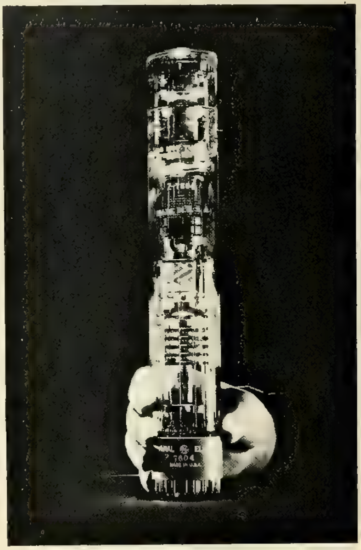
Products featured in this section have been selected from those to be displayed at the International Convention of the Institute of Electrical & Electronics Engineers, New York City, March 22-25.

New Product of the Week: Image Orthicon

An image orthicon, designed to reduce the volume, weight and power requirements of comparable camera systems, has been developed by General Electric Co.

These reductions will make the low-light-level image orthicon systems suitable for use in satellites, the company pointed out. Round-the-clock weather surveillance from an orbiting satellite is now technically feasible with the electrostatic tube, a spokesman added.

The Model Z-7804 tube measures 13.125 in. in length and weighs 11 oz. Power requirement is 1 watt. The tube controls the beam by electrostatic focusing and deflection, thereby eleminating the need for magnetic focus and reflection yokes and alignment coils. The device features a thin-film magnetic oxide target with a sensitivity 10 to 20 times that of glass targets, GE said. It has an S-10 or S-20 photocathode with spectral response characteristic of these surfaces.



Another version of the tube includes a fiber optic faceplate with an S-20 photocathode. When used in combination with visible, infrared or ultraviolet image intensifiers with fiber optic faceplates, sensitivity of the tube can be improved an additional 10 to 30 times. Resolution is approximately 600 lines.

Circle No. 151 on Subscriber Service Card

Klystron Power Supply

The Model Z815C universal klystron power supply is being marketed by Microlab/FXR. The unit features a digital readout dial for presetting of the 4,200-v, 360-watt beam supply and two separate reflector outputs. It offers a grid supply for positive or negative grid and a 0 to 15-v dc filament supply.

Regulation of the beam supply is 0.005% for line and load; maximum ripple is 2.5 mv RMS. A modulator section provides square wave, pulse, sawtooth and sine wave modulation to be applied to reflector I or the grid.

Circle No. 152 on Subscriber Service Card

Crystal Can Relay

A crystal can relay, requiring 100 mw operating power, is being marketed by Filtors, Inc.

The Series JW relay is an all-welded, 0.2-in. grid spaced unit, sealed in a near perfect vacuum without contaminating flux. Specifications include a temperature range of —65° to 125°C; dielectric strength of 1,000v RMS, 500v RMS between contacts; insulation resistance of 1,000 megohms, minimum. The unit can withstand vibrations of 30 g's from 5 to 3,000 cps and shock of 150 g's for 11 milliseconds.

Circle No. 153 on Subscriber Service Card

Frequency Counter

A solid-state frequency counter designed to meet military specifications is being marketed by Computer Measurements Co.

The Model 880 features a direct counting range up to 100mc. Range can be extended with a frequency extender plug-in available from the company. Time-based stability of the unit is one part in 10^8 per week. It has a built-in capacity for time-interval and multiple-period measurements.

Circle No. 154 on Subscriber Service Card

Recoder/Reproducer

A magnetic tape recorder/reproducer, designed for use in orbiting space vehicles, experimental aircraft and missiles, is being marketed by Leach Corp.

The MTR-3200 features an extra rugged construction said to make it particularly useful in drop-testing, rocket-sled testing, ground vehicle tests and oceanographic probes. It can withstand shocks of 10 g's, 11 ms 1/2 sine, and vibration of 10 g's RMS random operating with less than 3% p/p flutter. It is capable of operating through acceleration of 25 g's, a temperature range of —40° to 71°C and in 95% humidity.

The unit uses all solid-state plug-in modular electronics and offers direct or remote control. Speeds regulated within 0.25% from 1⅞ to 60 ips are available. Power consumption is nominally 55 watts at 28v dc. Frequency response ranges from 50 cps to 250 kc using direct recording or dc to 20 kc using FM recording. Extended bandwidths of 500 cps to 2.4 mc analog and dc to 800 kc FM are available on special order.

Circle No. 155 on Subscriber Service Card

Laser Accessory

An accessory to increase the single-pulse peak power output of any laser resonator using a rotating or oscillating reflector has been developed by TRG Div. of Control Data Corp.

The Daly-Sims device has a spectral range of 0.25 to 2.5 microns and can be fitted to an optical bench or mounting surface. It uses the phenomenon of total internal reflection in a multiple-reflection optical plate to increase the switching speed of a prism Q-switch.

The unit contains two Brewster angle plane-parallel optical plates. A total of 12 internal reflections are made on each pass through the system.

Circle No. 156 on Subscriber Service Card

Test Set

A series of multifunction test sets, designed to give convenience and versatility at both microwave and radio frequencies, is being marketed by Wiltron Co.

The units combine phase and level transfer characteristics with complex reflection coefficient measurements for a frequency range of 25 to 12,400 mc. Oscilloscope display of swept frequency data, meter readout and analog outputs for data storage and processing are provided.

The unit has a capability to measure signals down to —90 dbm with 0.1-degree resolution to —60 dbm; changing phase with 0.17-ms rise time or 2-kc bandwidth; and phase angle to 360 degrees with 180 degrees at a time on the meter face. Amplitude is measurable over a 60-db range with an accuracy of 0.1 db per 10 db by IF substitution techniques.

Circle No. 157 on Subscriber Service Card

WHO...WHAT...WHERE...

in the Missile/Space Industries!

SECTION B-1
MAJOR MISSILE/SPACE MANUFACTURERS
SECTION B-2
COMPONENT MISSILE/SPACE MANUFACTURERS
SECTION D
MISSILE/SPACE CONSULTANTS & SPECIAL SERVICES
EXECUTIVE BRANCH
FRANCE
WORLD SPACE DIRECTORY

Spring 1965 Edition

17,000 KEY PERSONNEL IN 4,250 COMPANIES
NAMES—ADDRESSES—PRODUCTS—SERVICES
—MISSILE/SPACE REFERENCE MATERIAL—

No matter what you're looking for in missile/space, you'll find your first lead in the WORLD SPACE DIRECTORY. Whether you're interested in reaching key industry or defense executives, bidding on a government contract, planning research or production programs, sizing up competition, or looking for a job . . . the WORLD SPACE DIRECTORY is your primary source of information.

RETURN THIS COUPON

WORLD SPACE DIRECTORY
New Edition
Spring 1965
50% Revised

$12.50 per copy—U.S., Possessions, Canada; $13.50 all other countries

☐ Copies ☐ Bill me ☐ Bill Company

Name
Title/Position
Street **City** **State** **Zip #**
Company Name
Division

1001 Vermont Avenue, N.W., Washington, D.C. 20005

let us move with you!

Six Weeks Is Required To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, if possible, the address label from your last issue . . . include your postal ZIP number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

◆ ◆ ◆

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Paris, France—11 Rue Condorcet; TRU 15-39

names in the news

SPENCER

FISHER

JATRAS

SELVIDGE

Edson W. Spencer: Elected corporate vice president of Honeywell, Inc., in charge of all international operations. He will direct the activities of 183 sales and service offices throughout the world and manufacturing plants in six countries, as well as U.S. export operations.

Robert E. Fisher: Elected vice president-research of the Marquardt Corp. He will continue direction and management of ASTRO, the central research division.

Stephen J. Jatras: Named executive vice president of Telex Corp. and president and chief executive officer of its subsidiary, Midwestern Instruments. He was formerly vice president of Lockheed Electronics Co.

Dr. Eugene C. Huebschman: Appointed manager of Special Project Dept. of the Earth Sciences Div. of Teledyne, Inc. He was formerly manager of advanced analysis of advanced planning for Pan American Airways' Guided Missile Div., Cape Kennedy.

Dr. Harner Selvidge: Elected a director of Cohu Electronics, Inc. He is also vice president and general manager of Meteorology Research, Inc.

Harold W. Snyder: Appointed to the board of directors of Greer Hydraulics, Inc. He is past president of the Beverly Hills (Calif.) Bar Association.

Ralph R. Sloan, Jr.: Elected president and treasurer of Latronics Corp. He was formerly vice president and controller, and is moving into the positions previously occupied by **Semon H. Stupakoff,** who remains as chairman of the board.

David H. Silvern: Appointed a vice president of the Clark Brothers Company, a division of Dresser Industries, Inc. He holds patents on components of gas turbines, engines, solar power plants and compressors, and was formerly president of D. H. Silvern and Co., an engineering consulting firm.

Joseph L. Smith: Appointed director of the Atomic Energy Commission's Division of Contracts. He will be responsible for planning, developing and maintaining over-all policies, standards and procedures pertaining to AEC contract management activities.

Dr. Paul Newman: Elected to the board of directors of SYNERGY Chemicals, Inc. He is assistant professor of chemistry a
Manhattan College in New York Cit
and has become associated with SCI's research staff.

John W. Findlay: Appointed directo
of Arecibo (Puerto Rico) Ionospheric Observatory for a year, beginning in the fal
He is deputy director at the Nationa
Radio Astronomy Observatory presentl
Arecibo is an Advanced Research Project
Agency (DOD)—and Air Force Office o
Scientific Research—funded project run b
Cornell University.

A. M. Harrelson: Elected vice presiden
in charge of acquisitions for The Bendi
Corporation. He was formerly treasurer an
chief financial officer with the Cran
Company.

Victor M. Sanders: Named as advance
projects manager at Lockheed Propulsio
Co. He will be responsible for the development of future solid motor propulsion applications.

Col. W. L. Starnes: Elected chairma
of the Cape Kennedy Project Stabilizatio
Board. He succeeds **Arthur G. Porche**
of NASA, and is Canaveral District Engineer of the U.S. Army Corps of Engineers.

James P. Ferguson: Elected presiden
and director of General Microelectronic
Inc., a subsidiary of The Pyle-Nationa
Company of Chicago. He is one of th
founders of GMe and has been executiv
vice president.

Donald Paisley has been named plan
manager for the Lincoln, Neb., plant o
Brunswick Corp.'s Defense Products Div
The plant is currently manufacturing second stage motor cases for *Polaris*.

Four appointments have been mad
in the new systems & research divisio
of Honeywell, Inc. **R. E. Clifford** has bee
named assistant general manager; **R. J**
McCracken, controller; **Dr. J. J. Renier,** director of technical operations; and **C. F**
Mueller, director of marketing.

John A. Granath: Appointed directo
of the electronics research division of II
Research Institute. He was formerly associate director of the division, and is succeeding **Virgil H. Disney** who is now vic
president.

—when and where

MARCH

nternational Convention of the IEEE, New York Hilton Hotel and New York Coliseum, New York City, March 22-25.

1965 Microwave Measurement Symposium, sponsored by Weinschel Engineering Co., Sherry Netherland Hotel, New York City, March 22-25.

Third Symposium on Thermophysical Properties sponsored by the American Society of Mechanical Engineers, the Thermophysical Properties Research Center and the Schools of Engineering at Purdue University, Memorial Center, Purdue University, Lafayette, Ind., March 22-25.

pring National Convention of the Society for Nondestructive Testing, Los Angeles, March 22-26.

2nd Annual Conference of the Western Section of the Society of the Plastics Industry, Hotel del Coronado, Coronado, Calif., March 24-26.

ricing and Negotiating Prime and Sub-Contracts in the Defense and Aerospace Industries, sponsored by Contract Management Institute, Sheraton Motor Inn, Huntsville, Ala., March 29-April 2.

Convention of the American Society of Photogrammetry and the American Congress on Surveying and Mapping, Shoreham Hotel, Washington, D.C., March 30-April 1.

eminar on Random Vibration, sponsored by MB Electronics, MB facility, New Haven, Conn., March 30-April 8.

dvanced Planning Briefings for Industry, sponsored by the DOD and NSIA, Conrad Hilton Hotel, Chicago, March 31-April 1.

Optical Society Meeting, Statler-Hilton Hotel, Dallas, March 31-April 2.

APRIL

EEE Seminar on Space Vehicle Reliability, Airport Marina Hotel, Los Angeles, April 2.

ixth Structures and Material Conference, sponsored by the AIAA, Riviera Hotel, Palm Springs, Calif. April 5-7.

nternational Symposium on Fission Product Release and Transport Under Accident Conditions, sponsored by the Oak Ridge National Laboratory, Oak Ridge, Tenn., April 5-7.

ymposium on Advanced Propellant Chemistry, sponsored by AIAA and ACS, Detroit, April 5-7.

ymposium on High Energy Physics, sponsored by the Institute of Physics and The Physical Society (England), Birmingham, Eng., April 5-8.

nternational Symposium on Techniques of Memories, sponsored by the French Society of Electronics Technicians and Radioelectricians, Paris, April 5-10.

International Nuclear Exhibition and Conference, sponsored by the Institution of Nuclear Engineers, Brighton, Eng., April 5-10.

Third Navy Microelectronics Program Conference, U.S. Naval Postgraduate School, Monterey, Calif., April 6-7.

1965 Annual Region III Meeting of IEEE, Robert E. Lee Hotel, Winston-Salem, N.C., April 6-8.

IEEE Computer Technology Conference, Thunderbird Hotel, Los Angeles, April 6-8.

Dynamics of Defense Marketing, sponsored by the National Defense Education Institute, Washington, D.C., April 6-8.

Anniversary Meeting of the Chemical Society, Glascow, Scotland, April 7-9.

1965 International Exhibition of Electronic Components and First International Exhibition of Audio Equipment, Paris, April 8-13.

23rd Annual Meeting of the National AeroSpace Services Assn., Washington Hilton, Washington, D.C., April 12-13.

Practical Aspects of Dynamic Programming, sponsored by the Detroit Research Co., Detroit, April 12-13.

Conference on Atomic Spectra and Radiation Processes, Oxford, Eng., April 12-14.

National Aeronautic Meeting and Production Forum, sponsored by the Society of Automotive Engineers, Inc., Sheraton-Park Hotel, Washington, D.C., April 12-16.

Dynamics of Defense Marketing, sponsored by the NDEI, Los Angeles, April 13-15.

15th Annual National Telemetering Conference, sponsored by the IEEE, ISA and AIAA, Shamrock-Hilton Hotel, Houston, April 13-15.

1965 Annual Region VI Conference of the IEEE, Las Vegas, Nev., April 13-16.

Advanced Planning Briefings for Industry, sponsored by DOD and NSIA, Marriott Motor Hotel, Dallas, April 14-15.

1965 Electronics & Instrumentation Conference and Exhibit, sponsored by ISA, Cincinnati Gardens, Cincinnati, April 14-15.

Specialists Conference on Thin Film Action Devices, sponsored by Johns Hopkins University, Baltimore, April 14-15.

New Horizons in Computation, sponsored by the Association for Computing Machinery, Marriott Twin Bridges Motor Hotel, Arlington, Va., April 15.

International Conference on Programming and Control, sponsored by the Air Force Office of Scientific Research and the University of California, U.S. Air Force Academy, Colorado Springs, Colo., April 15-16.

Symposium on Human Physiological and Performance Determinants of Manned Space Systems Design, sponsored by the American Astronautical Society and the Human Factors Society, California State College, San Fernando, Calif., April 15-16.

Advertisers' Index

ATLAS CHEMICAL INDUSTRIES, INC., AEROSPACE COMPONENTS DIV. 12
Agency—Harris D. McKinney, Inc.

BECKMAN INSTRUMENTS, INC., OFFNER DIV. 34
Agency—Erwin Wasey, Ruthrauff & Ryan, Inc.

BOEING AIRPLANE DIV. 40
Agency—Forbes, Inc.

CALMEC MANUFACTURING CORP. 13
Agency—Schaeper Industrial Adv.

CONSOLIDATED ELECTRODYNAMICS CORP. 7
Agency—Hixson & Jorgensen, Inc.

DEFENSE ELECTRONICS, INC. 8
Agency—GLM Associates, Inc.

DU KANE CORP., COMMUNICATION SYSTEMS 3
Agency—Connor-Sager Associates, Inc.

DYNALECTRON CORP. 4
Agency—Dawson MacLeod & Stivers

ELECTRONIC SPECIALTY CO. 48
Agency—Gaynor & Ducas, Inc.

GENERAL PRECISION, INC., KEARFOTT DIV. 37
Agency—Gaynor & Ducas, Inc.

LOCKHEED AIRCRAFT CORP. 27
Agency—Foote, Cone & Belding

McDONNELL AIRCRAFT CORP. 6, 47
Agency—John Patrick Starrs, Inc.

MARTIN CO. 25
Agency—Ketchum, MacLeod & Grove, Inc.

NORTH AMERICAN AVIATION, INC. .. 38
Agency—Batten, Barton, Durstine & Osborn, Inc.

SCIENTIFIC DATA SYSTEMS 22
Agency—Faust-Day Adv.

SPERRY GYROSCOPE CO., DIV. OF SPERRY RAND CORP. 33
Agency—Reach, McClinton & Co., Inc.

UNION CARBIDE CORP., CARBON PRODUCTS DIV. 11
Agency—J. M. Mathes, Inc.

UNITED AIRCRAFT CORP. PRATT & WHITNEY AIRCRAFT DIV. 2
Agency—Cunningham & Walsh, Inc.

This High Man

LAST WEEK WE PAID A VISIT to the little stone laboratory on the winter-scarred campus of Worcester Polytechnic Institute where Dr. Robert Goddard carried out some of his early experiments in rocketry.

It is impossible to contemplate that small building without some feeling of awe and amazement at all that has been accomplished in the years since Dr. Goddard set to work to make his vision of "moon-shooting" a reality.

The occasion was the March 16 celebration of Goddard Day at the school where, as an undergraduate, Goddard first demonstrated the talent and determination which were to characterize his work in the years to come.

We personally were interested to learn that he also was an editor—of the college yearbook. There, however, similarity of interests ends—for he also was a songwriter and we can't carry a tune in a bucket.

The broad range of Dr. Goddard's personality is an interesting contrast for those who believe in the stereotype of the dedicated scientist who locks himself in his lab away from everyday life.

Among his hobbies was landscape painting in oils. He was an avid reader of Kipling, Sir Walter Scott and Kenneth Roberts. He enjoyed music as a regular subscriber to the Worcester concert series. Photography was to him not only a hobby but a means of recording for posterity his early work in rocketry. Far from a recluse, he was the popular, witty president of his college class.

We recommend for your reading the biography of Goddard by Milton Lehman entitled "This High Man." For those who know Goddard only by reputation, it is an enlightening and fascinating account of a man whose dream was acknowledged as reality abroad before it was accepted in this country.

Indeed, only today is the honor coming to Dr. Goddard which he so justly earned. Congress now has proclaimed March 16 as Goddard Day. That is the anniversary date of his first successful rocket launch 39 years ago. That rocket traveled 184 feet in two and a half seconds, reaching an altitude of 41 feet. A small accomplishment by today's standards, but the start of man's efforts to reach into space.

We think a quotation from the Congressional bill is appropriate to underline his contribution:

"That the Congress hereby finds that rapid advances and developments in the fields of astronautics and related sciences are having an increasing impact on the daily lives of the people, the national security, and long-range human progress. It is therefore desirable and appropriate that steps be taken to promote greater public knowledge of the progress and achievement being brought about in these fields, and for that purpose to provide for special recognition and honor to Dr. Robert Hutchings Goddard, the father of modern rockets, missiles, and astronautics, and to designate and set aside a special day to honor his memory and his accomplishments."

Principal speaker at the Worcester Tech ceremonies honoring Goddard was Gen. Bernard A. Schriever, commander of Air Force Systems Command. The general, touching on plans for the *Manned Orbiting Laboratory*, once again brought home the tremendous strides taken since Goddard's first rocket launch.

But more important, Gen. Schriever called attention to the need for tenacity and vision in carrying out such accomplishments. In today's atmosphere, where there is all too much reluctance to push the state of the art in new programs, his words carry important meaning:

"It is very easy—and often more comfortable—to resist new ideas and bold new approaches. The much more difficult course is to give support to the new or unconventional. But the fact is that real progress lies in striking out in new directions . . . Dr. Goddard's mark of greatness is that he dreamed boldly, dared greatly and struggled vigorously to achieve his objectives."

GODDARD'S DREAM WAS THE OBJECT of derision 39 years ago. Who, we must wonder, is the dreamer today who is being ignored? Where is he? What is he working on that will change this world so vastly 39 years from now?

These are not idle questions. If we do not provide the atmosphere and support required for the acceptance of bold new challenges, the onward pace of U.S. science and technology will falter, then stop.

It is ironic that so much of our accomplishment in the missile/space field can be traced directly to the foreign threat to the nation. For it was unquestionably the Soviet missile threat which brought the funding for our long-range missiles that today serve as space boosters. Much of what we are attempting in the *Apollo* program is keyed to the race with the Soviets for the Moon. Funding for our unmanned probes can be directly related to what the Russians are doing. Every program manager in the industry is aware that the biggest boost his project can attain is a revelation that the Russians are hard at work in the same field.

We are heartily in favor of engaging in such competition. But we lament the fact that so much of our progress depends upon it. We must re-awake the pioneering instinct of the nation, that readiness to accept the stimulating challenge of something at which we may fail.

Gen. Schriever put it this way:

"I think that one of the important things to remember today is that Dr. Goddard had a far-reaching vision and the stubborn determination to push ahead toward its fulfillment. We cannot afford to overlook this kind of foresight. On the contrary, we need to recognize it and take advantage of it, because far-seeing vision lies behind all truly great achievements."

As we honor Dr. Goddard, let us not forget the legacy he left us in the example of his own life—the willingness to attempt something when there was no assurance of success. With this, he opened the Space Age.

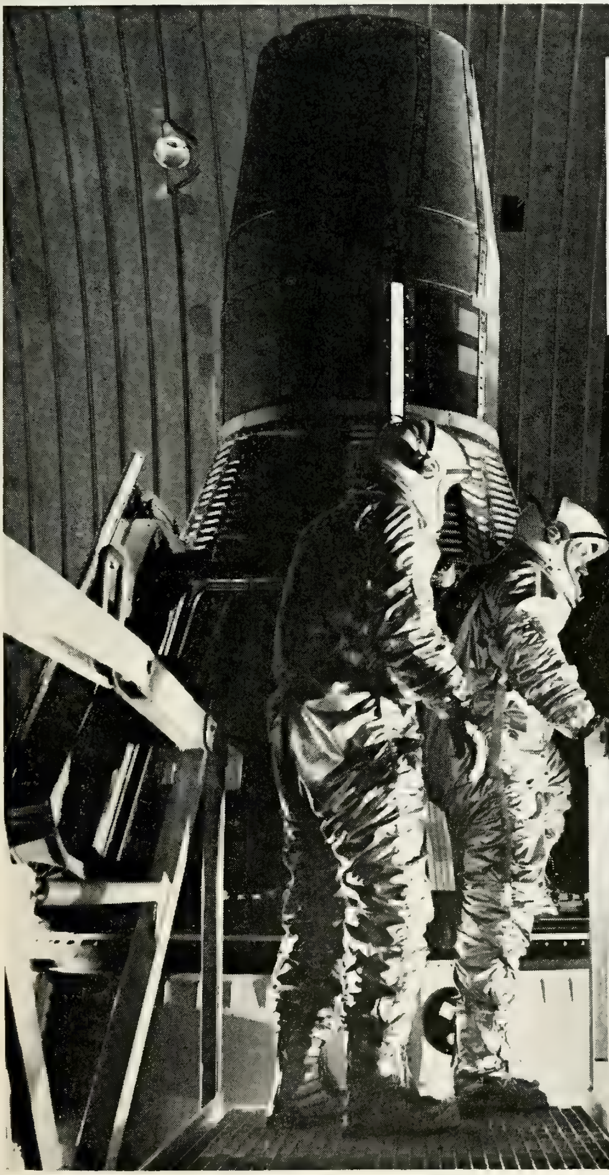
William J. Coughlin

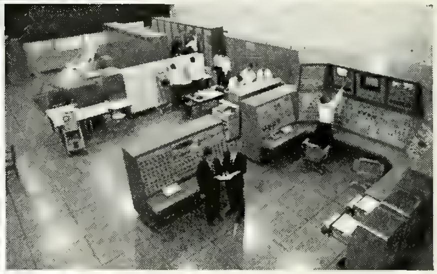
DEEP SPACE AT "GROUND ZERO"

When NASA's astronauts board their Gemini spacecraft it will be with the feeling of old hands at familiar jobs. Even ground crews will operate with the facility of seasoned experts. This is the way it must be, even though it will be a first for both men and machines—each person, each system functioning in unison.

McDonnell engineers designed and built the trainers and simulators for Gemini's orbital rendezvous missions as well as launch, orbital flight and reentry.

The Gemini Mission Simulator is one example of how the skills and facilities of McDonnell Electronics Division are applied to mirror desired situations through true simulation.





GEMINI MISSION SIMULATOR

Our brochure, "Skill in Electronics" will show you why McDonnell is a leader in end-mission related electronics such as Trainers and Simulators.

Write to:

MCDONNELL ELECTRONICS DIVISION

DEPT. 946 • BOX 516 • ST. LOUIS, MISSOURI 63166

APPLYING ELECTRONICS AS AN INTERDISCIPLINARY SCIENCE

St. Louis Bicentennial Space Symposium and Fifth National Conference on the Peaceful Uses of Space, May 26-27-28, 1965
For information, write: Box 7133, St. Louis, Missouri 63177

Circle No. 15 on Subscriber Service Card

Detects, identifies, destroys

In seconds. Not hours.

Now, one compact lightweight electronic package makes it possible to detect, identify and destroy enemy radar, all on the same recon flight. With this new system, hours or even days of waiting for data processing on the ground is reduced to seconds because data is processed in-flight. Electronic Specialty Co. has this system ready now, two generations ahead of industry expectations. Perfected after 3 years of company-funded development and now under military evaluation, the patent-pending ES airborne recon system has a built-in reci-strike capability.

ES is also in production on an advanced electronic aid-to-photo-interpretation system for today's high-speed recon aircraft.

By looking ahead in communications, countermeasures, and reconnaissance, Electronic Specialty Co. is finding answers ahead of time.

ES

ELECTRONIC SPECIALTY CO. 4561 Colorado Blvd., Los Angeles, California

Los Angeles, Calif. / Anniston, Ala. / Ft. Madison, Ia. / Harrisonburg, Va. / Hurst, Tex. / Pomona, Calif. / Portland, Ore. / Thomaston, Conn. / Toronto, On

Circle No. 16 on Subscriber Service Card

MARCH 29, 1965

APR 1965
HOUSTON PUBL

missiles and rockets

HE WEEKLY OF ADVANCED TECHNOLOGY

U.S. ARMY 22125

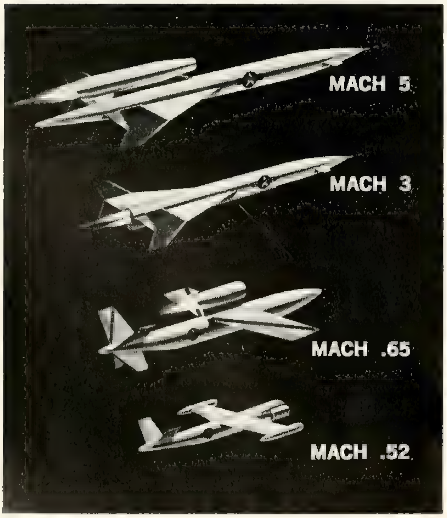
FOURTH ANNUAL

Beech "Imaginuity" in Missile Systems

MACH 7, ANYONE?

What will be the requirements for tomorrow's missile targets? What are the problems in building them? Beech "Imaginuity" is already seeking—and finding—the answers. The Beech missile above, designed to operate at speeds above Mach 7, is just one example of the way Beech is exploring the future—today.

If you want to pass this Beech missile target, you'd better be doing Mach 8—or better!



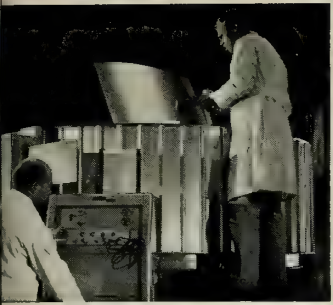
Now from America's first family of missile targets, comes the newest example of Beech "Imaginuity":

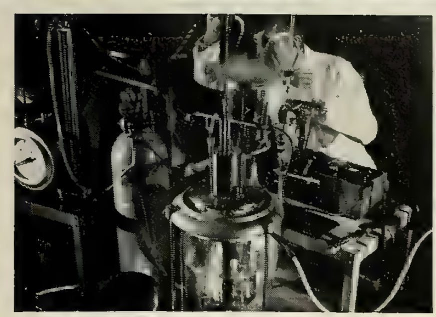
Today's modern air defense systems are only as effective as t shooting skills of the men who aim and fire them. To provide t realistic training needed to keep America's air defense units comb ready, Beech is building and has designed an entire family of miss systems to accomplish a variety of missions. They range in spe from Mach .52 to over Mach 7, with altitude capabilities from s level to over 100,000 feet.

Two Beech missile target systems, the propeller-driven U. Army MQM-39A "Cardinal" and the rocket-powered U. S. Na AQM-37A (KD2B-1), are already being produced in quantity. T AQM-37A is capable now of speeds above Mach 3. It gives toda most advanced weapon systems a realistic challenge to th capabilities.

This kind of successful experience in developing and buildi entire missile systems has given Beech a head start on the futu We are ready now to put Beech "Imaginuity" in design, develo ment, fabrication and testing to work on the even more advanc missile systems that will be required for tomorrow's training a air defense requirements. May we tell you more?

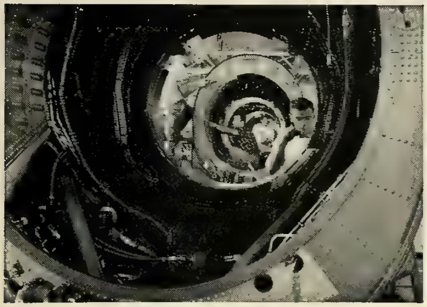
Other Beech Capabilities In Systems Management Include:

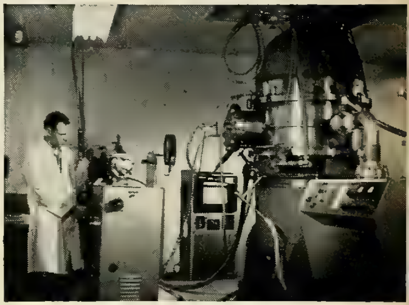

R & D...


Propulsion...

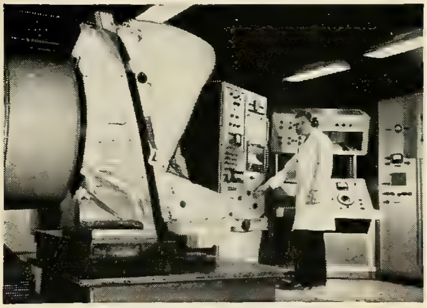
Auxiliary Power...

sile Target Systems


Manufacturing...


Space Simulation...

Facilities...


Complex Vibration...

Management...

low may we help you? To discover how the roven capabilities of the Beech organization can be uickly and efficiently put to work on your project, rite, wire or phone Contract Administrator, Aerospace Division, Beech Aircraft Corporation, Wichita, Kansas 67201. Beech stands ready and eager to accept complete systems management responsibility for your project right now.

Beech *Aerospace Division*

BEECH AIRCRAFT CORPORATION • WICHITA, KANSAS 67201

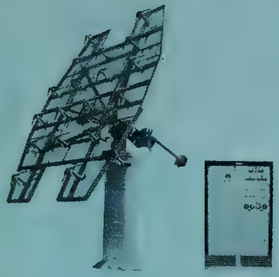
HELPING BUSINESS GROW FASTER: Only Beechcraft offers such a complete line of planes with so much speed, range, comfort and quiet to help business multiply the money-making decisions that each top man can make. That's how thousands of Beechcrafts have paid for themselves.

Executives: Write today for latest illustrated folders on ☐ Beechcraft twin-engine airplanes, ☐ Beechcraft single-engine airplanes. Address Beech Aircraft Corporation, Marketing Services Department, Wichita, Kansas 67201, U. S. A.

PROJECT MERCURY

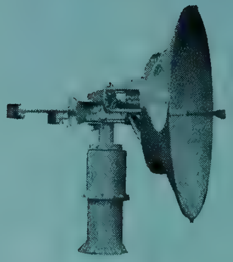
Dual quad-helix antenna systems for VHF-UHF telemetry-command functions

PROJECT GEMINI



VHF/UHF crossed dipole phased array telemetry tracking systems.

PROJECT GLOTRAC



S, C, X Band, monopulse or conical scan, parabolic antenna tracking systems

ANTENNA SYSTEMS

Canoga has designed, developed and installed complete antenna tracking systems for use at NASA/DOD instrumentation tracking ranges in support of all the important space programs. Canoga's engineering and manufacturing capability includes the major system components — Antenna, Pedestal, Control System, and Tracking Receiver.

canoga

CANOGA ELECTRONICS CORPORATION 8966 Comanche Ave., Chatsworth, California 91311
Telephone: (213) 341-3010
TWX (213) 341-5399

Circle No. 43 on Subscriber Service Card

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY
Volume 16, Number 13
March 29, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors
Charles D. LaFond .... Electronics
William S. Beller .... Engineering

Associate Editors
Lawrence J. Curran ...... Assistant Managing Editor
Heather M. David .... Space Medicine
Michael Getler .... Electronics
John F. Judge .... Propulsion/Materials
Robert L. Parker .... Copy Editor
Rex Pay .... Electronics
Hal Taylor .... NASA
James Trainor .... Military
Donald L. Zylstra .... Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach .... Art Director
Donald Strickland .... Assistant Art Director
Suzanne Montgomery .... Editorial Assistant
Sally Fosnight .... Editorial Assistant

BUREAUS
LOS ANGELES ..... 9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks .... Bureau Chief
NEW YORK .... 20 East 46th Street
Michael Getler
CAPE KENNEDY .... 507 Orange Ave.
Merritt Is., Fla.
MIDWEST .... 423 N. Quentin
John L. Zimmerman .... Wichita, Kan.
PARIS .... 11 Rue Condorcet
Jean-Marie Riche

EDITORIAL ADVISORY BOARD
Dr. Peter Castruccio
Alexander Satin
Conrad H. Hoeppner
Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton .... National Sales Manager
Paul B. Kinney .... Eastern Advertising Manager
Edwin J. Denker, Jr. ..... Western Advertising Manager
Kenneth C. Blanchard. Marketing & Research Director
John N. Carlin .... Director of Circulation
Paddy Nelson .... Circulation Promotion
R. Virgil Parker .... Director of Production
Barbara Wiener .... Advertising Services Manager

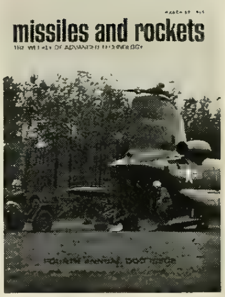
Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President .... Wayne W. Parrish
Senior Vice President .... Louis C. James
Vice President .... Fred S. Hunter

THE COVER



Army troops unload Little John missile from CH-47A Chinook helicopter in tactical exercise. Application of advanced technology developed by missile/space firms to the myriad problems of tactical warfare—from materials to mobility—is the theme of M/R's Fourth Annual DOD Issue. The special report begins on page 39.

MARCH 29 HEADLINES

GT-3 Triggers Move To Speed Manned Flight Schedule .. 13
Space Agency Reveals GT-3 Rendezvous Capability 13
Details of Man-Rated Titan II Propulsion System 19
NASA Limits Gemini Pilots to One Flight Each 20
Voskhod Success May Assist NASA Budget Request .. 22
Ranger IX Photos Suggest Apollo Crater Landing 26
New Satellite Proposed at IEEE Meeting 30
Phoenix To Vastly Boost Navy Fighter Armament 34

M/R'S FOURTH ANNUAL DOD ISSUE 39

Compiled under the direction of Military Editor James Trainor

Part I: Overview

Limited Warfare R&D Seen as Still in Infancy .. 40

Part II: Technology

Materials R&D Difficult To Coordinate in DOD .. 54
Electronics Needs Outstrip Tactical Emphasis . 63
Conventional Power Sources Still Favored 77
Morse Cites Significance of Basic Research .. 83

Part III: Programs

Small-Caliber Weapons Get Renewed Attention 94
Forward Air Defense Problem Concerns Pentagon 101
Strategic Experience Aids in Command & Control 109
Funding for Long-Range Mobility on Upswing 117
Stepped-Up Counterinsurgency Effort Continues . 125

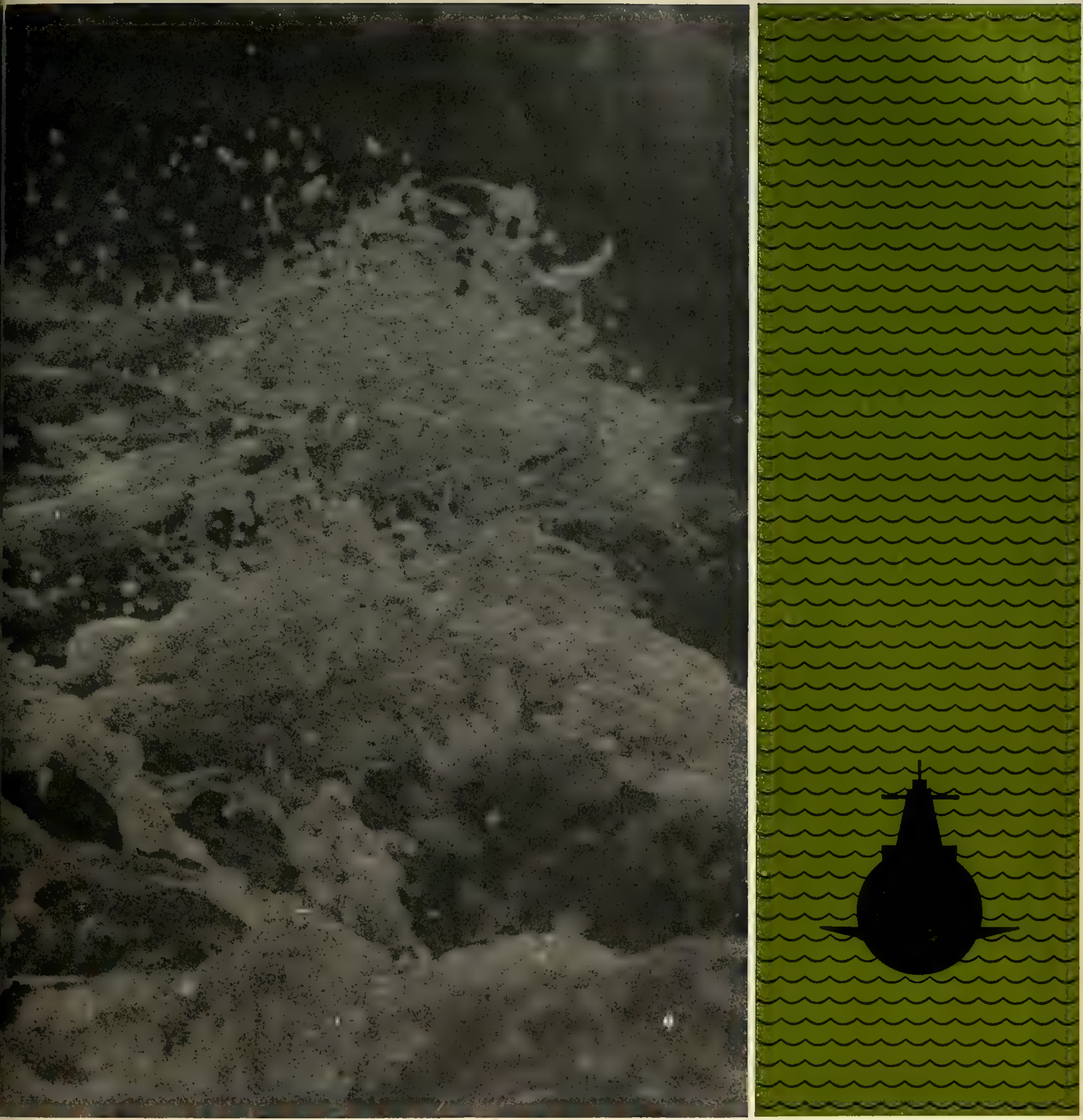
Organization Charts for Principal R&D Offices 130
Directory of Key Defense Procurement Contacts 143

DEPARTMENTS

Letters 9
The Countdown 11
The Missile/Space Week® 13
Products & Processes ... 153
Contracts/Procurements 166
Names in the News 168
When & Where 170
Editorial 172

49,475 copies this issue

"He maketh the deep
to boil like a pot..."

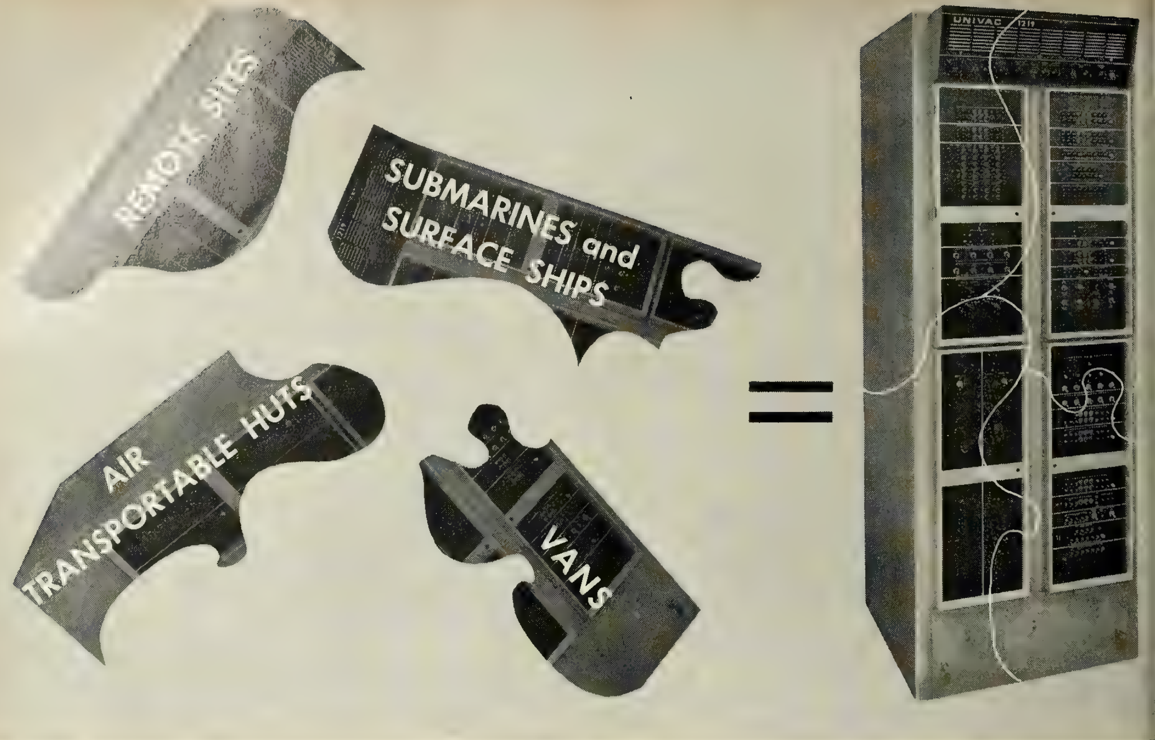


This was ASW, Old Testament version (*Job* 41:31).

ASW, 20th-century Navy style, is something else.

It is thousands of men, planes, ships and subs — tied together
by a staggering array of electronics.
It is long patrol flights, long months on station, lonely watches.
It is everything — fused into a potent, single-purpose defense system.
From the Arctic to the Antarctic — in, on and over the seven seas.
TRW provides systems integration and test support for this
vast and vital Navy mission.

TRW SPACE TECHNOLOGY LABORATORIES
THOMPSON RAMO WOOLDRIDGE INC.



WHICH PIECE OF THE PUZZLE IS YOURS?

The UNIVAC® 1219 makes everything fall into place. Compatible with our 1218 but faster and having greater capacity, the 1219 takes up no larger space. Reliable and Rugged, it is designed for installation aboard ships, over-the-road trailers, air transported "huts," command centers or submarines.

. . . Or most any other application you might think of.

Check your own spec sheet requirements with those found in the 1219:

- **REAL TIME**
- GENERAL-PURPOSE
- DESIGNED TO MIL-E-16400
- 18-BIT WORD LENGTH (DOUBLE WORD CAPABILITY)
- MAIN MEMORY—8K TO 65K WORDS; 2 MICROSECOND CYCLE TIME
- CONTROL MEMORY—128 WORDS; 500 NANOSECOND CYCLE TIME
- OPERATING SPEEDS—14 MICROSECOND MULTIPLY AND DIVIDE
- EIGHT INDEX REGISTERS
- INPUT/OUTPUT 4 TO 16 BUFFERED CHANNELS; UP TO 500 KC TRANSFER RATE
- 102 INSTRUCTION REPERTOIRE; SINGLE ADDRESS
- 29 UNIQUE INTERRUPTS
- 32-WORD PERMANENT MEMORY
- SIZE: 72″ x 26¼″ x 30½″
- COMPATIBLE WITH ALL **UNIVAC** MILITARY SYSTEMS
- SOFTWARE—ASSEMBLERS; SERVICE LIBRARY; SUBROUTINE LIBRARY; *FORTRAN*
- STANDARD PERIPHERALS

ANOTHER BIT OF WIZARDY FROM

UNIVAC®

UNIVAC Defense Systems Division ● Sperry Rand Corporation

Circle No. 74 on Subscriber Service Card

letters

MOL Simulation

To the Editor:

I want to pass on to you the high praise of our Bioastronautics engineers and scientists for the fine piece of reporting in your March 15 issue (p. 34) with the article by Rex Pay entitled "Analog, Digital Computer Combination Will Aid in MOL Mission Simulation."

Dr. Kraft, assistant head of our Bioastronautics Laboratory, Dr. Martindale and Fred Waite, head of our crew simulation work, all volunteered great satisfaction with the article, saying that it described the facility with extreme accuracy and, in fact, caught subtleties which generally escape.

Rockwell Hollands
Public Information
Lockheed Missiles & Space Co.
Sunnyvale, Calif.

Commercial Polaris Subs

To the Editor:

Having read with utter amazement (about) the study conducted by the Naval Electronics Laboratory at San Diego on the commercial use of *Polaris* submarines (COUNTDOWN, March 22, p. 9), it occurred to this office that money might be saved if they would just load a capsule with precision equipment and medical drugs for launch from Cape Kennedy to any underdeveloped country of their choice.

W. M. Huey
Senior Program Manager
Consolidated Electrodynamics Corp.
Arlington, Va.

Not spelled out but implicit in the item referred to is the fact that the suggested firing of critical cargo to underdeveloped countries without port facilities would amount to a pop-up launch covering a short distance.—Ed.

Ranger Projectiles

To the Editor:

Mr. Vance Haynes' proposal (Letters, M/R, March 15, p. 5) that an explosive projectile be fired from *Ranger IX* to be photographed after detonation by the spacecraft sounds like a split motor-type missile suggested several years ago. Proper design of the ejection system for the explosive projectile may be used to reduce the speed of the camera-bearing vehicle during the terminal phase and increase the amount of time for photographic observations at close range.

John E. Knights
Apollo Support Department
General Electric Co.
Daytona Beach, Fla.

For a NASA explanation of why proposals for such a projectile have not been adopted in the Ranger program, see Letters, March 22, p. 6.—Ed.

Beyond Saturn V

To the Editor:

I can certainly understand the feeling of awe which you expressed in your March 8 editorial. The accomplishments of building the *Saturn V* and its launch facilities can be reviewed in no other way. However, I believe it is highly dangerous to reach sweeping conclusions based on such emotion.

As a matter of fact, it is quite possible to build and launch vehicles much larger than the current *Saturn V*. NASA and industry have studied these problems for several years. Vehicles of more than 25 million pounds of thrust have been studied, with the conclusion that these vehicles can be launched and that such launches are practical.

This type of planning represents NASA's effort to keep up with the potential needs of the nation. Whether such large vehicles as those studied will ever become a reality depends not on their feasibility or potential advantage, but on the need of the nation's space program. Should our needs be great enough, we are ready!

Robert H. Lea
Littleton, Colo.

Gemini Delays

To the Editor:

In the Jan. 25 M/R you say "the *Gemini* program is still limping along, about two and one-half years behind schedule."

The implication is that perhaps NASA and the contractors are at fault for these delays.

Actually, the Congress and the White House must be blamed, for it was these people who refused NASA the necessary funds to move *Gemini* ahead on schedule.

Not all, but most of our delays in the race into space have been caused in Washington, D.C.—not at the Cape or at the contractor's manufacturing facility.

Gustav J. Clark
Clearwater, Fla.

Oceanography

To the Editor:

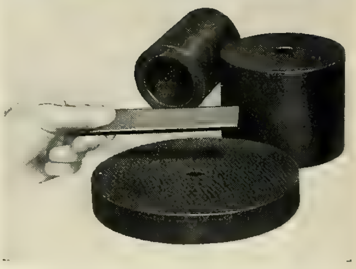
I read the item in M/R recently reporting that a bill has been introduced in Congress to set up a National Oceanographic Council on a par with the National Aeronautics and Space Council.

I hope that this legislation will pass into law and the U.S. will make a belated start toward exploitation of "liquid space" for the benefit of humanity. In my view, it is of far greater potential than outer space.

In addition, I trust your magazine will likewise intensify its coverage of oceanography—in all of its aspects.

J. T. McGuire
Boston

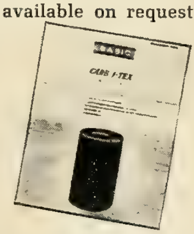
Announcing
Carb-i-tex
SUPER-CARBON



. . . the newest award winning super-strength structural material for high temperature environments to 5700°F.

- 20 times stronger than conventional high performance carbon and graphite materials.
- Extremely resistant to physical shock . . . thin-wall rings of CARB-I-TEX actually bounce when thrown against concrete.
- Lightweight . . . density is ~1.4 gr/cc
- 99.9% pure carbon or graphite . . . superior thermal stability . . . virtually immune to thermal shock . . . high resistance to erosion at high temperatures . . . no melting point . . . dimensionally stable.
- Corrosionproof . . . inert . . . not wetted by molten metals . . . electrically conductive.
- Can be formed to finished shape.
- Presently being used or considered for die-ring supports, high temperature bearings, electric furnace components, combination shielding/structural use for nuclear reactors, missile and ballistics exhaust nozzles, rocket engines, spacecraft leading edges, ablative structures.
- Development programs will be considered.

CARB-I-TEX is a family of materials produced by bonding together layers of one or more fiber forms of carbon or graphite, using elemental carbon as the bonding agent to form a lightweight, rigidly solid, pure carbon structure. Additional data available on request.



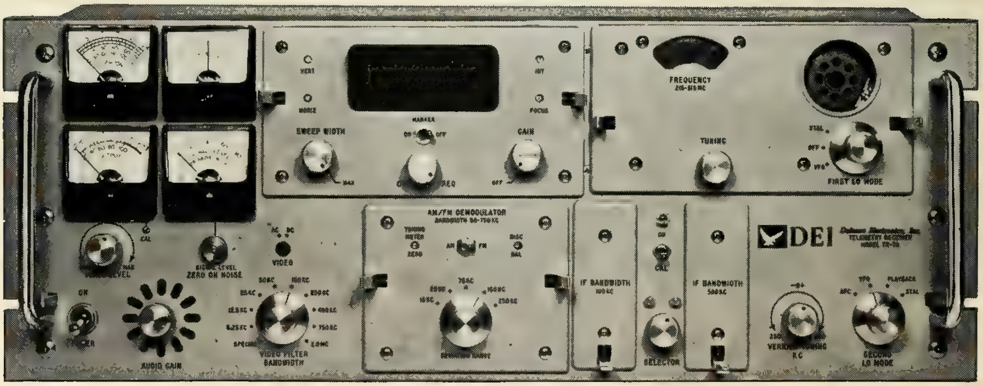
3842-142

BASIC CARBON
A CARBORUNDUM COMPANY
Blank and Walmore Roads, Sanborn, N.Y. 14132
Phone 716 • 731-3226

Circle No. 76 on Subscriber Service Card

This is DEI's Solid State Receiver

It's new
Tunes in the range of 100 to 2300 mc
Superior performance characteristics
The TR-711 is virtually spurious free
Sets the standard for comparison


VERT
NOISE
HOR
FOCUS
SWEEP WIDTH
MARKER
ON OFF
GAIN
MAX
FREQ
OFF
FREQUENCY
TUNING
XTAL
OFF
VFO
FIRST LO MODE
CAL
SIGNAL LEVEL
ZERO ON NOISE
AC DC
VIDEO
AM/FM DEMODULATOR
TUNING METER
ZERO
AM FM
DISC
BAL
IF BANDWIDTH
CAL
IF BANDWIDTH
DEI
ON
AUDIO GAIN
VIDEO FILTER BANDWIDTH
SELECTOR
KC
AFC
VFO
PLAYBACK
XTAL
SECOND LO MODE

The TR-711 Receiver is modular in construction and can be supplied with a complete complement of plug-in modules including RF tuning units from 100 to 2300 mc, IF amplifiers with 10 kc to 3.3 mc bandwidths, AM, FM, and phase demodulators, and plug-in spectrum display unit, oscilloscope, predetection up and down converter, or high capture ratio discriminator. Any combination of plug-in modules can be utilized, thus providing unlimited receiving combinations adaptable to any known or projected telemetry system.

Characteristics and accessories are described in Bulletin TR-711.

Defense Electronics, Inc.
Rockville, Maryland

DEI
RESEARCH
DEVELOPMENT
MANUFACTURING

ROCKVILLE, MD. (301) 762-5700, TWX: 301-427-4660; **SHERMAN OAKS, CALIF.** (213) 872-2870, TWX: 213-732-2742; **COCOA, FLA.** (305) 632-5442; INT'L., **ROCKVILLE, MARYLAND.**

Circle No. 50 on Subscriber Service Card

The Countdown

WASHINGTON

Gemini Schedule in State of Flux

Space agency officials have made no decision yet as to the length and number of *Gemini* long-duration missions. The first one, *GT-5,* is expected to last at least seven days. If everything works well, it might be extended to 10 days. Officials will then decide whether the tight quarters of the spacecraft preclude a 14-day mission, now slated for *GT-7.*

AF Gemini Role Still That of Banker

The Air Force has some $20 million in this year's budget for participation in the *Gemini* experiment program. At this point, NASA officials say, no consideration is being given to further AF participation, such as use of its astronaut corps as pilots in the series, or the actual taking over of later missions by the Air Force.

DOD Funds Get Tentative Trimming

Defense R&D requests totaling $6.7 billion were reduced $504.6 million in the FY 1966 defense authorization bill approved Mar. 23 by the House Armed Services Committee. Expected to be reported to the full House this week, the measure also includes a $149.5-million reduction in procurement requests. Breakdown of the requests as they affect each armed service showed cuts in new obligational authority for R&D including $126.2 million from Army's $1.438 billion, $165.9 million from $1.472 billion for Navy, and $212.5 million from $3.147 billion for the Air Force.

LBJ Defers Lunar Proposal

President Johnson probably will not make a specific recommendation for lunar exploration this year, NASA Administrator James E. Webb told the Senate Space Committee. Webb said the President would consider what the next step should be after the U.S. has more information about what weightlessness does to men in space, how well the rendezvous and docking operation can be accomplished, and how well the *Apollo* LEM stands up in testing. After this, Webb estimated, the President will submit "some reports that generate a real discussion" before he makes a decision.

Concern over Gemini Disbanding

The NASA Legislative Oversight Subcommittee of the House Space Committee headed by Rep. Olin Teague (D-Tex.) has put a high priority on an inquiry into the future of the *Gemini* program. Teague told COUNTDOWN the committee was very concerned that the manufacturing team, which is nearing the end of its task, would be allowed to disperse before a decision is made.

260-in. Tests May Cost $2.2 Million

A fee of $150,000 rests on each successful firing of the four half-length 260-in. solid motors which will be tested by Thiokol and Aerojet, if Congress approves the reprogramming action to allow NASA to complete Phase I of the program. As it now stands under the incentive contracts separately negotiated with the two companies, they will receive a combined minimum of $1.6 million, even if all four should fail. If all are successful, the maximum will be approximately $2.2 million. Had there been no overruns in the program—which took it to $56.5 million from a target of $41.9 million—they could have split a maximum fee of $3.8 million.

NASA Defends Soviet Data Policy

NASA Administrator James E. Webb said that Congress' criticism of NASA for keeping mum on Soviet space information is unjustified. The classification is imposed by DOD, he said, and there is nothing in NASA's charter which requires dissemination of information of Soviet activities—only its own.

Schriever Discounts Phoenix on F-111A

Although the Air Force plans to include an air-to-air missile in the mix of weapons to be carried by the F-111A, it is doubtful whether "customers" in that service would favor using the Navy's highly sophisticated *Phoenix* in this role, in view of the F-111A's primary fighter-bomber mission in which air-to-ground weapons have first priority. This is the view expressed by Gen. B. A. Schriever, AFSC commander, who noted that the Navy's F-111B, used primarily in a defense capacity, can more easily afford some of the weight and space penalties imposed by the complex *Phoenix* system.

Finger Reiterates SNAP Economy

Joint AEC-NASA program chief Harold Finger flatly told the Senate space committee that the SNAP 8 system, with its rotating turbogenerator equipment, is the most economical and feasible method of converting heat to electric energy in nuclear reactor systems. Mating a thermoelectric generator to the SNAP 8 reactor would yield half the efficiency of the original, putting out only 15-20 kw, he said. A new, heavier reactor would have to be developed to get the 35 kw available in the SNAP 8 system, he said. Previously, AEC chairman Glenn T. Seaborg had indicated the possibility of using a thermoelectric cycle, saying that he was not convinced that the turbogenerator system was the best way of accomplishing the conversion.

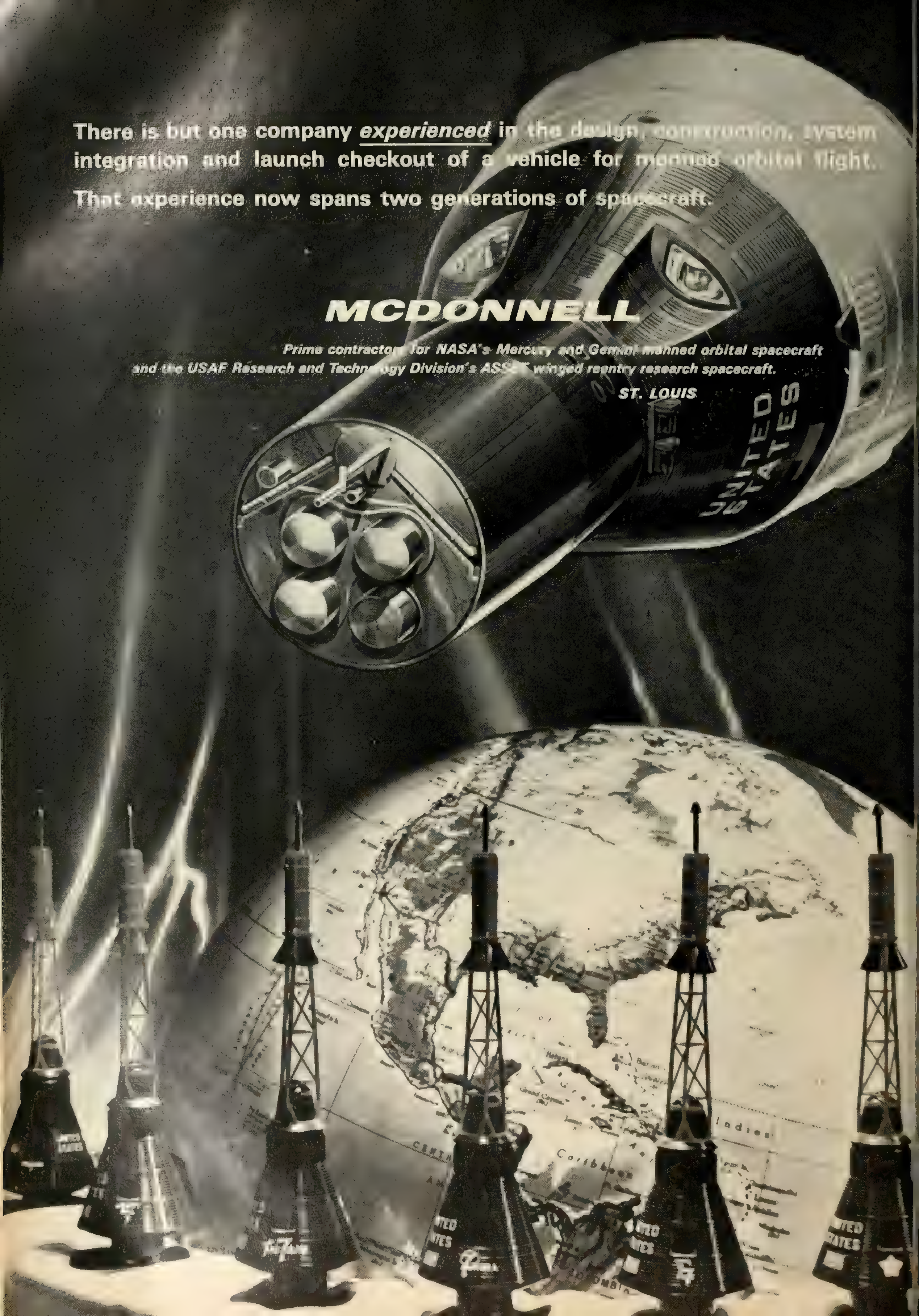
INDUSTRY

GD Finishes Unique All-Stage Test Plant

General Dynamics/Convair has finished building a $6-million test facility for NASA in which *Atlas-Centaur/Surveyor* combinations will be checked out for lunar missions. First such facility constructed to handle all stages of a space vehicle, it has about 22,500 ft. of floor space. *Centaur/Surveyor* will be erected vertically in an 89-ft. tower, while the *Atlas* booster will be mounted horizontally in a 100-ft.-long bay.

Army Night-Vision Needs Spell Big Market

The Army's intense interest in development of lightweight, long-range night vision devices (M/R, March 22, p. 18) could lead to a procurement program worth more than $250 million over the next several years, according to Army Mobility Command officers. "These devices," they report, "are needed in unprecedented quantities for vehicles to permit high-speed convoy movements under cover of darkness." There are several other applications that could swell this market even further.



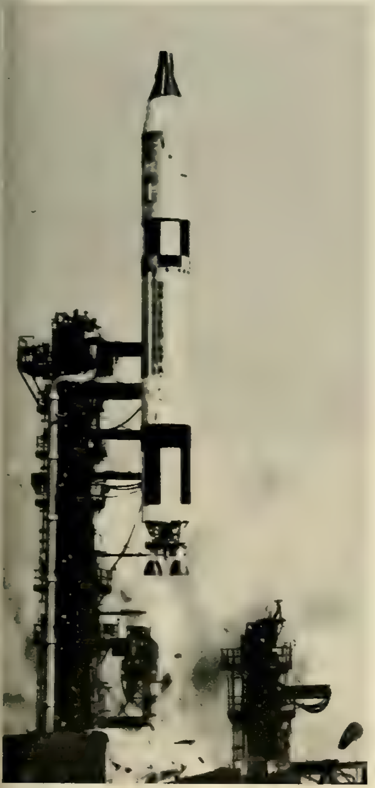
There is but one company *experienced* in the design, construction, system integration and launch checkout of a vehicle for manned orbital flight.

That experience now spans two generations of spacecraft.

MCDONNELL

Prime contractors for NASA's Mercury and Gemini manned orbital spacecraft and the USAF Research and Technology Division's ASSET winged reentry research spacecraft.

ST. LOUIS



Four Manned Geminis Now Seen for 1965

by Hal Taylor

CAPE KENNEDY—NASA officials—spurred by the success of *Gemini 3* have launched a drive to accelerate the U.S. manned spaceflight program.

Charles W. Mathews, *Gemini* project manager at the Manned Spacecraft Center, told MISSILES AND ROCKETS he hopes to cut the time between launches to two months.

Mathews' plans could add a fourth manned flight to the 1965 schedule, which would then call for the first U.S. rendezvous attempt as well as a long-duration (seven-day) mission.

- **Maneuvering 'first'**—His comments were made following the completely successful three-orbit flight of *Gemini 3* on March 23, which put this country back into the manned space race.

The four-hour and 53-minute flight with Command Pilot Virgil "Gus" Grissom and Pilot John Young at the controls was the first two-man U.S. space mission.

It chalked up a Space Age first, according to NASA scientists, when Grissom successfully directed the first powered orbit maneuvering of a spacecraft in space.

The orbit-changing actions were taken on three different occasions by the firing of the attitude controls and the newly developed Orbital Attitude Maneuvering System (OAMS).

In the first action, Grissom changed the *Gemini 3* path around the Earth from a normal orbit of 121 n. mi. apogee and 87 n. mi. perigee to an almost circular orbit of 91.3 n. mi apogee and 85.6 n. mi. perigee. This occurred near the end of the

GT-3 Had Rendezvous Capability

CAPE KENNEDY—A top NASA official declared here that if there had been an *Agena* stage in orbit, the *Gemini 3* spacecraft could have rendezvoused with it.

Christopher C. Kraft, flight director for the mission, made the statement in tribute to the spacecraft's orbital altitude maneuvering system, which was used twice to change its orbit.

"If an *Agena* was up there, we would have rendezvoused and docked," he said.

The orbit changing occurred on the first and third orbits when the OAMS system was used to put the spacecraft in circular and highly elliptical orbits.

After the successful maneuvers were completed, officials here hailed the OAMS performance as completely nominal. They were especially pleased because the system will eventually be used to power the final approach when the *Gemini* spacecraft docks with the *Agena* upper stage.

First full rendezvous attempt by NASA will be the *Gemini-Titan 6* mission which may be made before the end of this year. It will be preceded by a practice rendezvous attempt on *GT-5*—the long-duration seven-day mission.

On the fifth flight, a pod will be released from the *Gemini* spacecraft and the astronaut team will practice approaching it by firing the OAMS system.

On *GT-6*, the *Agena* will be launched first and put into a parking orbit around the Earth. Then the *Gemini* will be launched in an attempt to hook up with the upper stage during the first orbit.

Much more sophisticated rendezvous attempts are planned for flights in 1966. This will include LEM ascent rendezvous, which will be used in Project *Apollo,* and LEM abort rendezvous which will be used in *Apollo* if an emergency arises as the LEM descends to the lunar surface.

As for the Russians' recent extravehicular activities, officials would not say when this country might duplicate them. They did say that the Manned Spacecraft Center was developing the technology for use in *Gemini,* but they would not pinpoint it to any one mission.

They said, however, that a practice attempt will be made on *GT-5*. On that flight, an astronaut will open the hatch, stand up and stick his head outside the spacecraft.

← Circle No. 130 on Subscriber Service Card

first orbit as the spacecraft passed over Texas.

During the second orbit, attitude-control thrusters were fired for a short period to make about a 1/50-degree change in the orbital plane angle.

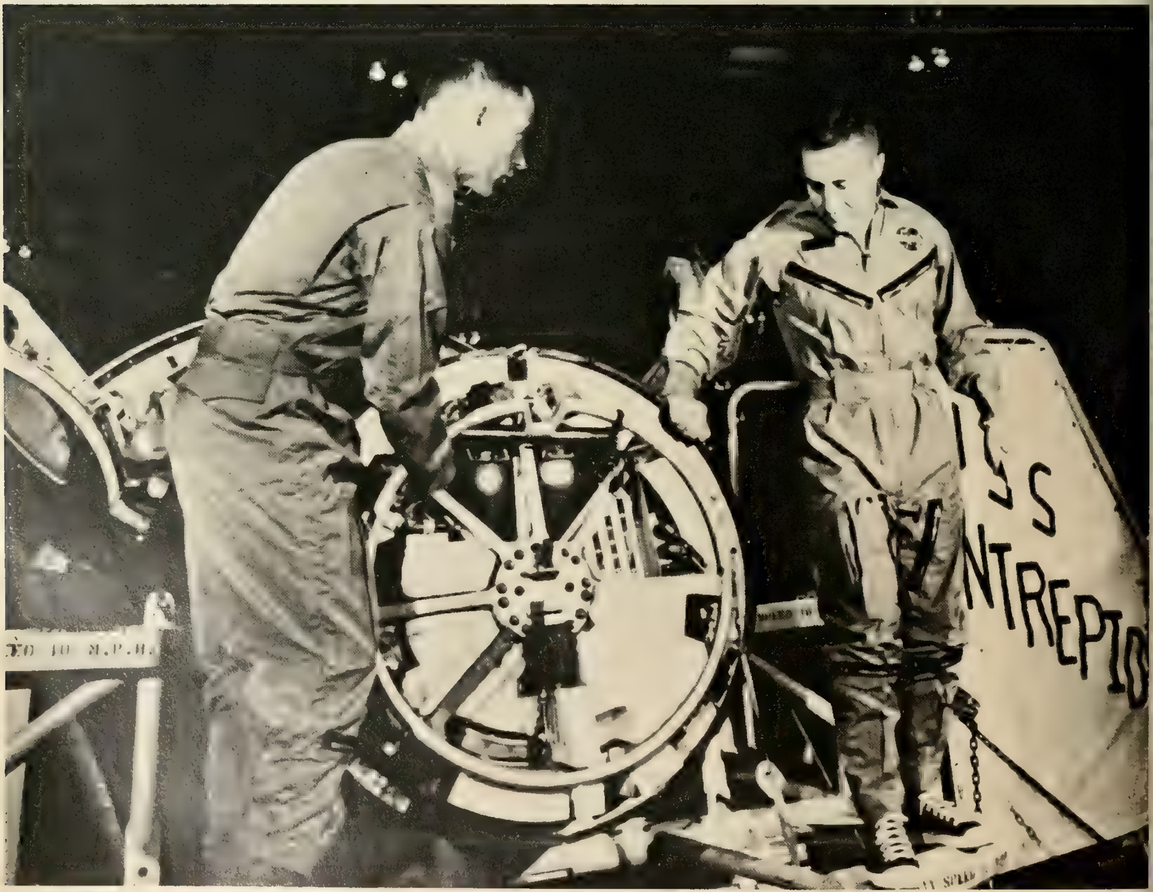
At the beginning of the third orbit, the OAMS system was fired again to put the spacecraft in a highly elliptical orbit ranging from an apogee of 91.3 n. mi. to a low point of 50 n. mi. This put *Gemini 3* at almost re-entry altitude, where the Earth's atmosphere could be used to slow down the spacecraft to re-entry speed.

- **Near nominal**—The two-stage *Titan II* launch vehicle—developed by the Martin Co.—blasted the *Gemini 3* spacecraft off from Cape Kennedy at 9:24 a.m. EST after an almost flawless 420-min. countdown.

Only one short hold was encountered—at T minus 35 minutes—when a leak was detected in an oxidizer line in the *Titan II's* first stage. This was fixed by a simple one-turn tightening of a valve with a wrench.

After the almost perfect flight, the astronauts were plucked from the

TOP: Astronauts Young (left) and Grissom wait in bobbing capsule as technician works to open hatch. BOTTOM: Aboard recovery ship USS Intrepid, Young (left) and Grissom examine GT-3 capsule. The astronauts were taken from the capsule by helicopter and flown to the Intrepid, which then proceeded to the capsule. The carrier picked up GT-3 two hours after splashdown.



All metal in Gemini crew compartment structure is titanium.

emini's strong, light-weight Titanium structure ets pace for next generation spacecraft and aircraft

The NASA Gemini spacecraft's load-bearing structure is virtually all titanium. It is light, strong, reliable. It shows how practical titanium is for both supersonic aircraft and next generation spacecraft.

At its simplest, it consists of titanium skin, supported by titanium spars, stiffeners, fittings, rings; joined by resistance and fusion welds. Why titanium? Two of the strongest reasons: outstanding properties and a history of reliability.

Titanium's properties include high strength-to-weight in both tensile and yield, outstanding toughness, immunity to atmospheric corrosion, excellent fatigue strength and long-life creep resistance... at temperatures from −423F to 800F and higher. To find all these properties in one metal is unique.

Titanium's performance record is matchless in the high temperatures and heavy loads typical of high speed flight. Item: three million trouble-free hours in the North American F-100. Item: six years of reliable flight in McDonnell Aircraft's Phantom II. Item: titanium is three percent of Boeing 727 airframe. Reason: titanium saves money by eliminating dead weight.

Mercury spacecraft was built of titanium. It is natural that McDonnell, which built Mercury, should use titanium for Gemini... seven different grades to meet specific mechanical needs. No limitation in size either. Forged rings, for example, are as large as 96 inches in diameter; sheet as thin as 0.010 inch.

Two lessons can be drawn. Titanium is the logical metal for high-performance aircraft construction. And Titanium Metals Corporation of America, which supplied metal for all these programs, is your best source. TMCA, as the nation's only organization devoted exclusively to titanium, supplies all grades, all products, all sizes—and all the technical assistance you require.

Write for 16-page digest of titanium's physical, mechanical properties and fabrication characteristics. Covers all grades.

TIMET®
titanium

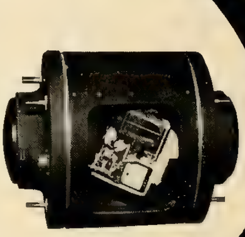
TITANIUM METALS CORPORATION OF AMERICA
233 Broadway, New York 7, N.Y.
NEW YORK • CLEVELAND • CHICAGO • DALLAS • LOS ANGELES

Circle No. 88 on Subscriber Service Card

What
happened?

EVERYTHING – just as we planned it! When this rocket sled roared down the track at Holloman AFB in repeated test runs, it proved what we already knew: Lear Siegler's new Low Cost Inertial Measurement Unit takes the shock and vibration of missile flights while retaining its high accuracy and reliability.

If you are involved in the design or production of tactical missile systems, you'll want to know much more about LSI's LCIMU. You'll be interested in its accuracy, its size and its maintainability. The cost? Well below that of any comparable stable platform on the market. Add to this the ruggedness and reliability —as proved in the sled tests—and you will realize that Lear Siegler's stable platform capabilities fit right into most existing and planned tactical missile systems.



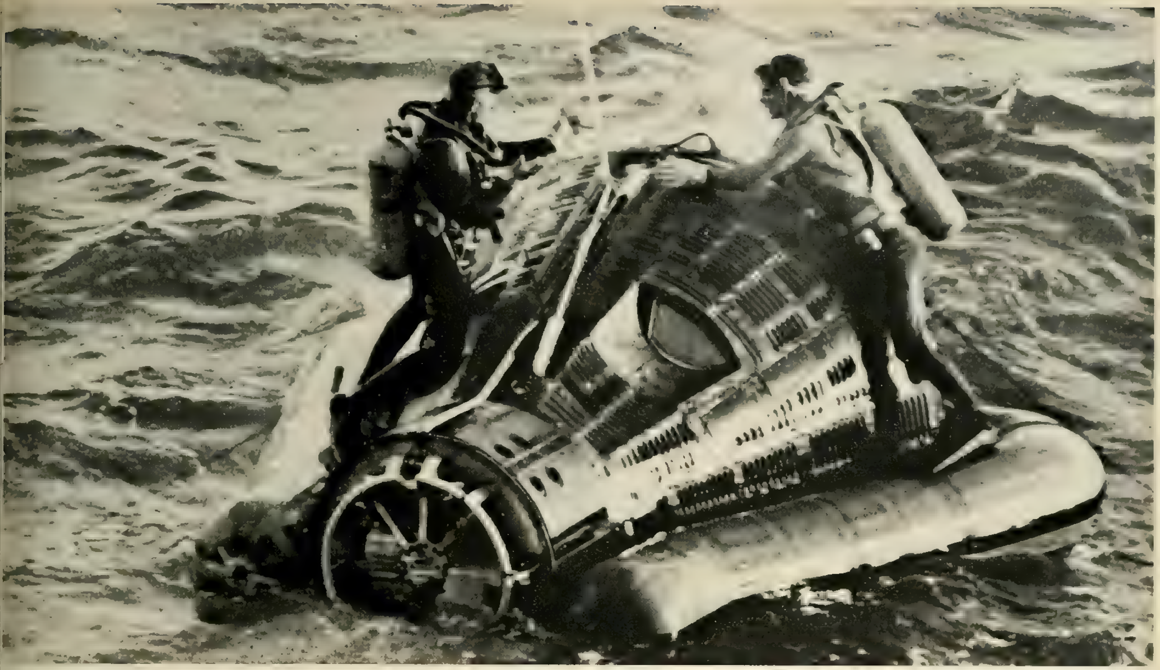
LSi

Complete test results available. *Write today. We'll send you a copy and full specifications on the new Low Cost Inertial Measurement Unit.*

LEAR SIEGLER, INC.

INSTRUMENT DIVISION
4145 EASTERN AVENUE, S. E.
GRAND RAPIDS, MICHIGAN 49508

Circle No. 78 on Subscriber Service Card



NAVY FROGMEN stand on flotation collars while preparing to open GT-3 capsule. The flotation rig provides additional buoyancy to the spacecraft. The device was added to the program after Grissom's Mercury capsule, Liberty Bell 7, sank in 1961.

Atlantic Ocean 50-60 miles northwest —short—of the designated impact point some 70 miles from Grand Turk Island.

After a short medical checkup on the aircraft carrier USS Intrepid, doctors said both Grissom and Young were in fine physical and mental shape.

• Gathering steam—The drive to quicken the pace of U.S. manned space activities is illustrated by the short period—only 63 days—between the unmanned *Gemini-Titan 2* flight and *Gemini 3*.

Mathews said that, while the schedule calls for a three-month interval between *GT-3* and *GT-4*, "we hope to beat it by a considerable amount." He said that some of the time could be shortened by dropping or reducing some of the testing that experience has shown may not be necessary. The factors in cutting the turn-around time will not be in the spacecraft or launch vehicle but in such things as mission planning and flight crew training.

Mathews citied the *Gemini 3* turn-around time as a good target. Other officials indicated that the target may be met for the planned four-day orbital *Gemini 4* mission. The spacecraft for the flight has already arrived at Cape Kennedy and the launch vehicle was delivered just as *Gemini 3* began.

The MSC official also declared that NASA has no plans at this time to make any changes in the flight objectives of any of the future *Gemini* missions.

He denied reports that MSC has decided not to attempt a 14-day flight because of the relatively small *Gemini* flight compartment. He said, however, that if early flights indicate that this will be a problem, the long mission may be re-evaluated.

He also denied persistent rumors that the space agency may turn over the last five flights of the 10-flight schedule to the Air Force. "There is no consideration being given by NASA or MSC to dropping the last five flights," Mathews said.

• Other experiments—Three additional experiments were aboard the spacecraft—an attempt to carry out radio transmission through the previously impenetrable re-entry communications blackout, and tests of effects on sea urchin eggs and white blood cells. Results are still to be determined.

• Unanimous acclaim—Mathews and other NASA officials here were unanimous in their praise of the *Gemini 3* mission and the performance of the spacecraft and launch vehicle systems.

In addition to citing the first orbital maneuvering of a spacecraft, Dr. George Mueller, associate administrator for manned space flight, said the flight marked the first demonstration of re-entry control by an astronaut and the first use of the *Syncom* satellite to communicate with a manned space vehicle.

The flight also chalked up another milestone in that the astronaut team received instantaneous readouts of the spacecraft's velocity in feet per second. This will be a mandatory tool for any astronaut team attempting a rendezvous mission. Previously, such information had to be acquired from ground command and tracking stations.

The performance of the *Titan II* was nearly perfect. First-stage cutoff at 152 seconds after launch was only two seconds before the planned cutoff.

Second-stage cutoff was also slightly premature. This occurred at 334 seconds rather than the planned 338 seconds. As a result, the spacecraft was injected into orbit at an altitude of 84.8 n. mi. Project engineers had wanted to achieve orbit at 87 n. mi. This, however, was well within requirements.

As far as the spacecraft was concerned, Mathews said that while some minor problems did develop, he did not believe that any one was serious enough to force a delay in the upcoming *GT-4* mission. He added, however, that a final fix on the problems would have to await study of the data and discussions with the astronaut team.

In outer space, all the pieces better fit.

They **will** fit. Interface control for an incredible number of sub-systems can be accomplished when each contractor subscribes, without reservation, to the concept of team play. All the way from the first word of the contract through to rocket tractors (picture, above) hauling cargo in space.

At United Technology Center, our capabilities include intelligent coordination with other contractors and suppliers. Our technology—propulsion. Solids, liquids, hybrids, ranging from powerful boosters to delicate variable-thrust motors for landing and docking.

Just as important, our capabilities include a deep **identification with the total mission,** not just our part of it.

UTC United Technology Center DIVISION OF UNITED AIRCRAFT CORPORATION U A

ASSOCIATE PRIME CONTRACTOR FOR THE AIR FORCE'S TITAN III PROGRAM.

Circle No. 49 on Subscriber Service Card

• **Yaw problem**—One technical problem was the continuous drifting of the spacecraft in a yaw position. It was theorized that the trouble stemmed from a slight oxidizer leak, but officials could not pinpoint it from the data received and communications from Command Pilot Grissom. They believed, however, that it was a mechanical problem rather than a failure in the electrical portion of the attitude control system.

Grissom controlled the problem by firing small thruster rockets to bring the spacecraft back to the proper attitude.

Another problem encountered during the flight was the failure of a dc-to-dc converter. Grissom simply went to a backup secondary system and the flight continued.

Shortly after the astronaut team was recovered, officials could still not explain the problem during the astronaut-controlled re-entry which forced the spacecraft to land 50 to 60 miles short of the planned impact point.

One theory proposed was that Grissom had not heard the bank angle transmitted by the flight ground command station.

This could have been caused by garbled communications. He was asked to put the spacecraft in a 45-degree bank angle which—with the re-entry system working perfectly—would have put him down in the desired landing spot off Grand Turk Island.

Officials said he may have believed that the command sent from the ground was to put the spacecraft in a 55-degree angle. That angle would have put the spacecraft impact point just about 50 to 60 miles short of the target—which is where the spacecraft hit the ocean.

Dr. Mueller pointed out that of 30 major spacecraft systems, 29 worked perfectly.

These included the environmental control system. Both the cabin and suit temperature were exactly the same as temperatures recorded during vacuum tests before the flight.

Other systems whose performance was praised included the re-entry rockets and the digital command system.

• **OAMS praised**—The operation of the orbiting altitude maneuvering system also received accolades from project officials. During the first orbit, two thrusters with a thrust of 85 lbs. each were to provide an additional forward thrust of 50 fps to achieve the circular orbit.

Later, the OAMS system was fired rearward for 1.24 seconds to put the spacecraft into an elliptical orbit on its third turn around the Earth.

Spacecraft splashdown into the Atlantic occurred at 2:18 p.m. EST. Because of the long distance from the planned impact point, recovery was slower than expected.

Because of the heat inside the spacecraft, the two astronauts removed their spacesuits while still inside the capsule. A flotation device was placed around the spacecraft by Navy frogmen. They were joined by Air Force paramedics in the operation.

The two astronauts—picked up by a helicopter—reached the deck of the aircraft carrier Intrepid at 3:30 p.m. EST. The spacecraft was lifted aboard the ship at 5:01 p.m.

The communications test was activated by Young as the spacecraft plunged through the Earth's atmosphere at an altitude of 300,000 ft.

Special Engines Provided Push

THE FIRST- AND second-stage man-rated engines, developed for the *Titan II Gemini* launch vehicle by Aerojet-General Corp., use nitrogen tetroxide as the oxidizer and Aerozene-50 as fuel.

The propellants are chilled before loading. This increases the density and effectively puts more energy into the launch vehicle. The two bootstrap first-stage engines generate 420,000 lbs. thrust, using 9,360 gallons of propellant per minute.

The engines themselves require a minimum countdown—the only pre-launch function brings the propellants up to a certain level within the unit. The fire signal ignites a small solid charge which initiates the turbopump operation.

This starts the propellants through their cycle into the combustion chamber. Ignition is hypergolic. All control systems are redundant, and roll control during launch phases is handled by exhausting the turbine gases through a small, swiveling nozzle.

The single second-stage engine is a bootstrap unit generating 100,000 lbs. thrust with the same propellants.

TOUGHEST STRAIN GAGES MADE...

Microdot's patented, weldable strain gage family provides:

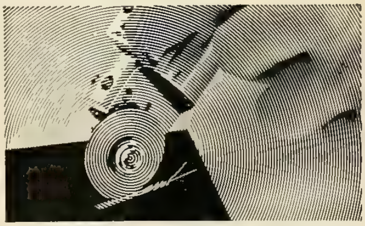
■ CONTINUOUS HIGH-TEMPERATURE OPERATION...at 650°F (static) and 1500°F (dynamic)

■ RADIATION RESISTANT... and impervious to corrosive liquids, live steam, cryogenic applications and elevated hydrostatic pressures

■ ELECTRONICALLY WELDED... in less than two minutes to become a fused part of practically any metal structure

■ MANY CONFIGURATIONS... including half bridges, full bridges and a true dummy strain gage

■ NEW LOW-COST STRAIN GAGES...now available for operation to 650°F...provide same superior features except custom temperature compensation.



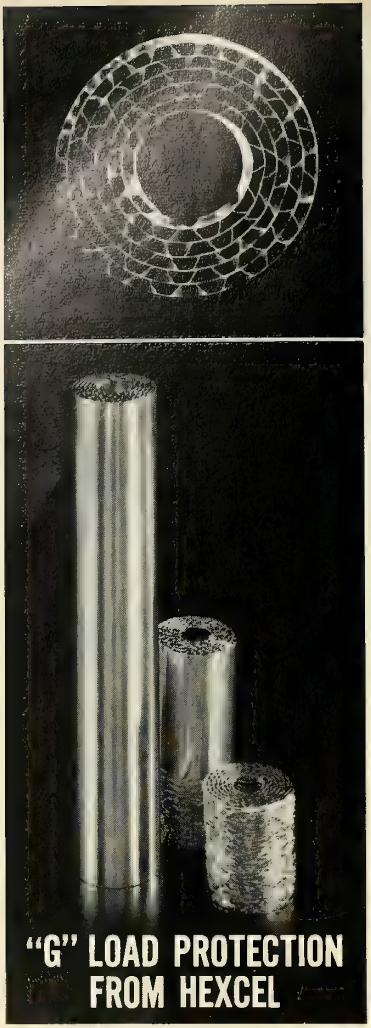
An efficient aid to application of Microdot strain gages and thermocouples is its Model MT-809 Rollectrode. The Rollectrode averages 32 spot welds per inch, operates at 60 cycle ac, 115 v, draws approx. 0.4 amp.

Write direct for Bulletin SG-1, or use reader service card.

MICRODOT INC.

220 Pasadena Avenue, So. Pasadena, Calif.
Overseas: Microdot-Varec NV, (Brussels)

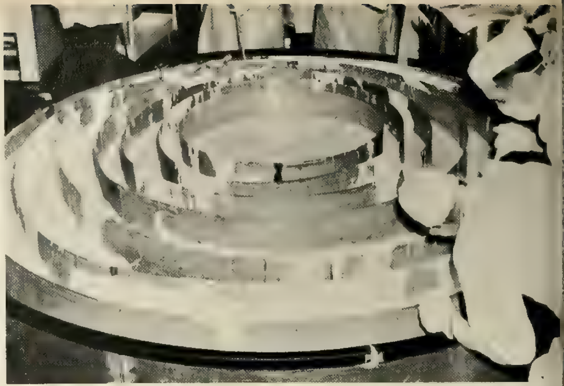
Circle No. 87 on Subscriber Service Card



- This material gives more efficient energy absorption for high slenderness-ratio tube forms than any material known.
- It is cylindrical aluminum honeycomb.
- It is called TUBE-CORE®.
- It can be designed for crush strengths ranging from 40 to 4,000 p.s.i., to suit most any environment and life expectancy.
- It requires no lubrication and costs far less than hydraulic units.
- TUBE-CORE® is custom-designed to meet exact energy absorption requirements.

For descriptive literature, call or write to:

HEXCEL PRODUCTS INC
World leader in research and manufacture of honeycomb core materials.
Executive Offices: 2332M Fourth St., Berkeley 10, Calif.
Applications Engineering Offices: Huntsville, Ala., (205) 536-0936; Inglewood, Calif., (213) OR 8-4121; Havre de Grace, Md., (301) WE 9-2900; Arlington, Tex., (817) CR 4-2578


WHITE SILICON rubber compound prepared by Dow Corning Corp. is poured into a 9-ft.-dia. mold at McDonnell Aircraft Corp. to complete ablative heat shield for GT-3.

About 16 lbs. of water was injected into the ionized plasma sheath surrounding the spacecraft during the 2.5-minute period.

The communications blackout is caused by the extremely high temperature generated by an object reentering Earth's atmosphere. The heat ionizes the air and creates a plasma sheath which surrounds the object—effectively eliminating radio communications with it. Throughout Project *Mercury* both voice and telemetry communications were lost during this period.

During the *Gemini* re-entry, water was injected in extremely brief timed pulses to test a theory that fluids would reduce the amount of ionization in the sheath to a level where communications would be possible.

The water expulsion system was fitted to the inside surface of the spacecraft's right landing gear. It weighed a total of 85 lbs.

Young's activation of the switch opened a solenoid shut-off valve and allowed nitrogen gas pressurization of the water storage tank. The switch also started a mechanically run injection sequence timer. This, in turn, activated the injection nozzle solenoid valves at their programmed times to allow injection of the water into the spacecraft flow field.

● **Eggs & cells**—The other experiments tested the effects of zero-g on the growth of sea urchin eggs and the interaction effect of zero-gravity and radiation on white blood cells.

Detailed data on each experiment will not be available until final analysis of measurements taken during and after the flight.

In the sea urchin test, the effect of zero-g on the eggs was tested during fertilization and cell division.

A series of samples similar to the ones in the spacecraft will be developed at the launch site for control purposes. At a designated time, the eggs and sperm will be united to start the growth cycle. After a specified time, the fixative solution will be applied to stop growth.

The white blood cells experiment is designed to prove whether radiation and zero-gravity acting in concert can produce unexpected effects greater than the sum of their individual effect.

In addition to the blood cells, samples of blood taken from the astronauts before the flight will also be exposed to radiation and zero-g conditions.

One Gemini Flight Per Astronaut

CAPE KENNEDY—Dr. George E. Mueller, NASA associate administrator for manned space flight, revealed here that the *Gemini* program will serve as a training ground for as many U.S. astronauts as possible.

He indicated that no astronaut will fly more than one mission in the series. This apparently rules out a repeat performance for the *GT-3* team.

There are 22 astronauts in the corps who have not yet flown a mission. With nine more flights on the schedule, almost all could get orbital time.

At the same time, it was learned here that spacecraft for the program are moving rapidly along the testing and manufacfacturing lines at the McDonnell Aircraft Corp. St. Louis plant. The fourth *Gemini* spacecraft last week was in the 30-ft. testing chamber awaiting shipment to the Cape this week.

Circle No. 79 on Subscriber Service Card

GEMINI
LAUNCH VEHICLE TEAM

hi-shear's separation nut program signally honored by

MARTIN COMPANY

Designated "critical parts" by Martin Company, Hi-Shear's Separation Nuts are used for launch tie-down and stage separation on the Gemini-Titan II Launch Vehicle.

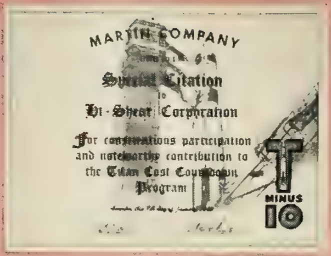
A "critical part" is just that . . . critical to the success of Gemini's missions and to the lives of its two-man crews.

Hi-Shear is one of only 30-some other firms supplying 54 vital parts in each launch vehicle singled out by Martin-Baltimore and Air Force engineers from more than 6000 suppliers to the Gemini-Titan II program.

If your spacecraft project requires "critical," flight-certified ordnance hardware, Hi-Shear offers a variety of separation systems and components, initiators and EBW devices that meet or can be readily adapted to your requirements.

Remember, too . . . Hi-Shear also offers versatile, high-strength fastening and bolting systems for primary structural application.

hi-shear
CORPORATION
2600 WEST 247TH STREET
TORRANCE • CALIFORNIA


MARTIN COMPANY
Special Citation
to
Hi-Shear Corporation
For conscientious participation and noteworthy contribution to the Titan Cost Countdown Program

T MINUS 10

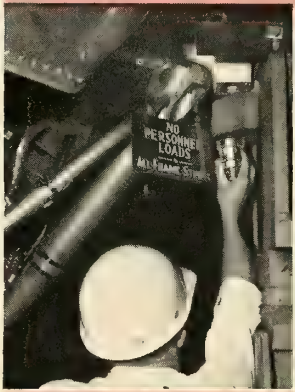
Value engineering at Hi-Shear Corporation resulted in a substantial cost reduction accomplishment in the Air Force-Titan ICBM program.

In earning the "T-Minus 10" citation, Hi-Shear was cited by Martin Denver for outstanding cost reduction efforts.

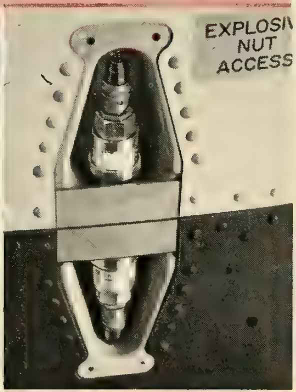
M
4536

Quality assurance responsibility at Hi-Shear is exampled by the use of the Martin Quality Acceptance Stamp assigned by Martin Denver to authorized Hi-Shear inspectors.

This means Hi-Shear is entrusted with the responsibility of acceptance for Martin of qualified ordnance hardware.



A pair of 1¼ diameter Hi-Shear Separation Nuts used with a threaded stud at each of four attach points hold the Gemini-Titan launch vehicle to the launch ring. Each SN2121-10 Nut has a minimum axial tensile strength of 180,000 pounds and fully operates while under 130,000 pounds.



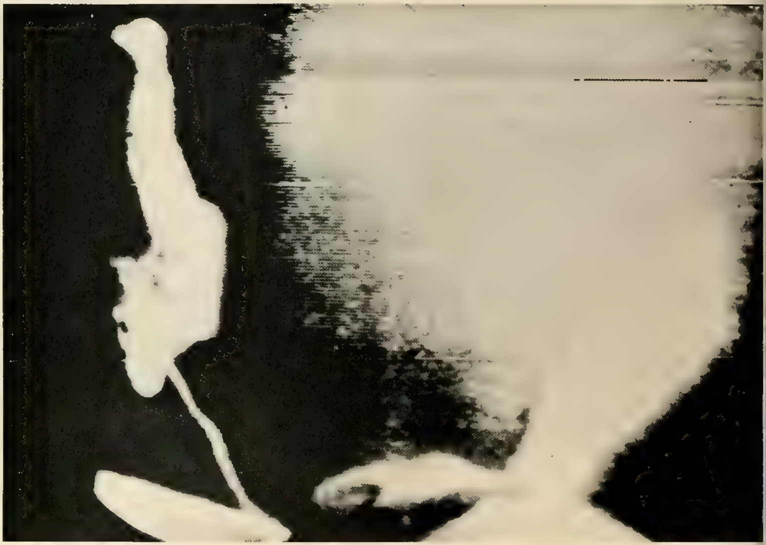
Another pair of ⅝ diameter Hi-Shear Separation Nuts join the two stages of the launch vehicle at another four points. Each SN2120-5 Nut can operate while bearing a 30,000 pound tensile load.

Both type nuts were subjected by Martin to extensive Flight Certification and Qualification Tests. These nuts are capable of complete separation in .005 second with the recommended Hi-Shear Power Cartridges after being subjected to temperatures ranging from −125° to +300°F and be operable at pressures from ambient to hard vacuum. Other type Separation Nuts by Hi-Shear can achieve separation in .003 second or less, under similar conditions.

U. S. AND FOREIGN PATENTS APPLIED FOR.

Soviet Moon Statements Give Congress Pause on Proposed NASA Budget Cuts

by Heather M. David



TOP: Cosmonaut Alexsei Leonov floats outside Voskhod II spacecraft anchored by tether line. BOTTOM: Pack on Leonov's back supplied oxygen and purified the gases he exhaled. Future packs will contain extravehicular propulsion devices.

REPORTS FOLLOWING the 26-hour spaceflight of the *Voskhod II* that the USSR is indeed racing for the Moon could give NASA a mighty assist in winning restoration of cuts administered to the *Apollo* program.

Although the flight itself, which began at 10 a.m. Moscow time (2 a.m. EST) March 18, and ended at 12:02 p.m. March 19 (4:02 a.m. EST), was in progress while the House Manned Spaceflight subcommittee was wielding its knife, it did not deter a faction led by Rep. James Fulton (R-Pa.). The cut, reported to be $103 million, was opposed by the subcommittee chairman, Rep. Olin Teague (D-Tex.)

Concerning the Soviet flight, Teague told M/R: "It was no surprise to us; we have been expecting this or even more for some time." Other top space officials expressed the same reaction. However, the flat statements about the Soviet Moon program emanating in the wake of *Voskhod II* could make the difference in getting the cuts largely restored by the full House Science and Astronautics Committee, which meets in the next two weeks to settle the NASA authorization bill.

At least two statements came from Soviet scientists in responsible positions in the Moon effort. At a televised press conference in Moscow, space official Vasily Seleznev said "the target now before us is the Moon." He added that it would come "in no distant future."

In another broadcast, the chief of the visual tracking station operation, Prof. Yelizavetskiy, discussed U.S. experiments in Hawaii in which the volcanic surface area is being used to simulate Moon conditions. He said "Science does not yet know the exact nature of the Moon's surface, but there is no doubt that it will receive this information first-hand and, of course, it will be Soviet first-hand information. The launching of the *Voskhod II* and Leonov's space walk strengthens the confidence that the first people on the Moon will be Soviet people."

Although the existence of a Russian lunar goal has been recognized

NEW
S-BAND
SYSTEMS
TRANSMIT
HIGH
FREQUENCY
DATA
CONIC

SYSTEM SPECIFICATION HIGHLIGHTS

ALL SOLID STATE TRANSMITTERS

FREQUENCY RANGE:
UHF telemetry bands, L-band or S-band, Crystal controlled

POWER OUTPUT:
3 watts minimum under all environmental conditions and supply voltage variations stated

POWER REQUIREMENTS:
28VDC ±4 VDC, less than 1.75 amperes

RADIO FREQUENCY INTERFERENCE:
Meets IRIG 106-60 for antenna conducted and radiated spurious and MIL-I-26600 for box and power line conducted and/or radiated.

MODULATION CHARACTERISTICS:

FM-DC COUPLED
Sensitivity: Available up to 1 MC/volt p-p
Input Impedance: 20K ohms shunted by 4PF
Response: Within 1.5 db from DC to 1 MC
Distortion: 2% maximum (total harmonic)

FM-AC COUPLED
Sensitivity: Available up to 1 MC/volt p-p
Input Impedance: 50K ohms shunted by 3 PF
Response: Within 1.5 DB from 5 CPS to 1 MC
Distortion: 2% maximum (total harmonic)

TEMPERATURE RANGE:
—30°C to +80°C

VOLUME:
34 cubic inches

WEIGHT:
30 ounces

ALL SOLID STATE CONSTANT BANDWIDTH SUBCARRIER OSCILLATORS

SUBCARRIER CHANNELS:
AIA Channels 1C through 22C (12.5 KC — 187.5 KC)

DEVIATION:
±2KC all channels

INPUT:
0 to 5 volts or ±2.5 volts (others on request)

INPUT IMPEDANCE:
500 K ohms minimum for channels 1C through 8C, 1 Megohm minimum for channels 9C through 22C

INPUT ACTIVITY:
Source impedance variation 0 to infinity produces less than ±2% of bandwidth frequency change

LINEARITY:
±0.25% of bandwidth deviation from best straight line

INPUT INTELLIGENCE RESPONSE:
Within 0.5 DB from DC to 2000 CPS

DRIFT:
Less than 1% of bandwidth in 8 hour period after 15 minute warm-up at 25°C

TEMPERATURE:
Center frequency stable with ±3% of bandwidth from —10°C to +85°C based on best straight line. Less than ±1% sensitivity variation

OUTPUT AMPLITUDE VARIATION:
Less than 1 DB

OUTPUT DISTORTION:
Less than 1%

SHOCK:
±0.5% of bandwidth for 100 G's for 11 milliseconds duration in each major axis

ACCELERATION:
Linear accelerations up to 100 G's produce less than ±1.0% frequency shift

VIBRATION:
±1.0% of bandwidth variation for 20 G's from 10 CPS to 2000 CPS in each major axis

VOLUME:
1.7 cubic inches

WEIGHT:
2.2 ounces

CONSTANT BANDWIDTH ON ALL CHANNELS!

Higher frequencies for missile and space telemetry will mean greater data resolution. Conic, today, is in full production on a complete line of the S-band systems destined to come into such wide use within the next few years.

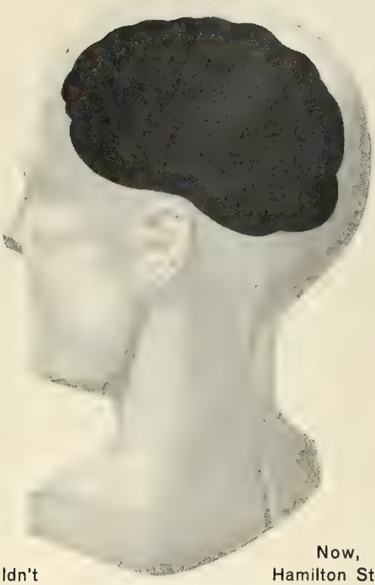
Heart of these systems is a new miniature, solid state S-band transmitter. It weighs only 30 ounces, has a cubic volume of less than 34 inches, but provides a 3 watt output.

Another significant advance made in the new Conic systems is the use of constant bandwidth subcarrier oscillators on all channels. These enable missile systems designers to fully meet the stability requirements imposed by IRIG without the need for translation techniques employed in the past.

Conic would welcome an opportunity to present to space engineers the complete story of the new Conic S-band telemetry systems. Consult your regional Conic Sales Representative, or write, wire or phone. **See Us: At Booth 900, NTC . . . Shamrock Hilton, Houston, Texas, April 13-15; At Booth 99, ITC . . . Sheraton Park, Washington, D.C. May 18-20.**

CONIC Corporation
7915 Balboa Avenue • San Diego, California 92111

Circle No. 75 on Subscriber Service Card



GRAY MATTER MATTERS MOST

You didn't prep at St. Grottlesex? Honestly, we couldn't care less. What matters most to us about our engineers is their gray matter. Not gray flannel, 8-button skinny suits. Nor do we care if the wife is Junior League Chairman or Little League Coach. Hamilton Standard has earned a reputation for regarding and rewarding its engineers on their skills and contributions. Fair enough?

We believe our assignments have the diversity and the dynamism to be worthy of top-rated professional talent. Our projects reveal a broad range of capability: environmental control systems, engine controls, starters and turbomachinery, air induction controls, propellers, low thrust propulsion systems, electron beam technology, ground support equipment, microelectronics, thrust vector controls, bioscience research and spacecraft life support systems. Specifically, typical assignments include environmental controls for the Apollo Lunar Excursion Module, the space suit and life support pack to be worn by astronauts in orbital rendezvous and during their exploration of the moon's surface. There are over one thousand graduate engineers and technicians offering a blend of every engineering discipline. And today there exist exciting career openings in almost every field.

Now, what else has Hamilton Standard to offer?

Superb, privately-owned facilities, for one thing. For instance, a recently completed space simulator for manned missions permitting tests at a simulated altitude of approximately 1,500,000 feet.

Our men are encouraged to keep pace with the state-of-the-art of their specialty by continuing their education. There are in-plant technical courses, lectures and seminars. Tuition-paid advanced study at Trinity College, University of Connecticut and Rensselaer Polytechnic Institute is also available. There is no danger of "engineering obsolescence" at Hamilton Standard.

So much for the company climate. What about the majority of your hours, those *away* from the job? Hamilton families have an enviable choice of urban, suburban and rural housing in picturesque Connecticut . . . generally just minutes from the plant. While the area is rich in nearby recreational and cultural facilities, it is also just one hundred miles from the metropolitan advantages of New York and Boston.

This is the ideal moment to discuss a career with Hamilton Standard. Reply in detail, including present salary, to Mr. A. J. Fehlber, Hamilton Standard, Windsor Locks, Connecticut, an equal opportunity employer.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
UA

for a number of years by such experts as Dr. Eugene Konecci, manned spaceflight specialist for the Space Council, Dr. Charles Sheldon and Dr. Edward Welsh, executive secretary of the Council, the recent statements seem to be leading to a greater realization in Congress that the Soviets intend to beat the U.S. to the Moon.

- **Flight characteristics**—Altitude of the flight was reported at 107.5 mi. perigee, and 307.5 mi. apogee, making it the highest manned spaceflight. Previous altitude record was set by *Voskhod I*, which reached 254 mi. at apogee. Period of the *Voskhod II* spacecraft was 90.9 minutes, with an inclination to the equator of 65 degrees.

The Soviet flight apparently ended in near-disaster Friday after the pilots—Col. Pavel Belyayev and Lt. Col. Alexei Leonov—missed an order to start retrofire and were forced to make an additional orbit, landing during the 18th orbit. The craft came down in a snow-covered forest near Perm, a city 725 miles east-northeast of Moscow at the foot of the Ural Mountains—a place obviously not picked for the landing site.

The pilots apparently had some difficulty in the automatic control system, and had to override the controls. It was the first landing controlled by the Soviet pilots, but it is not believed that the control system gives the craft the ability to change orbits, as does *Gemini*.

There was a delay of 4½ hours before Soviet news broadcasts announced the safe ending of the flight, apparently as rescue crews traveled over the rough terrain to recover the cosmonauts. The usual landing site is located about 600 miles away on a flat plain.

The Soviet pilots are assumed to have breathed 100% oxygen before the launch, and perhaps used face masks during the one and a half orbits before Lt. Col. Alexei Leonov made his foray out of the capsule to become the first man in true space. Leonov spent 10 minutes in an unpressurized airlock in his spacesuit before emerging out of the hatch. Soviet physiologists said that all cosmonauts will have to undergo a denitrogenation period of at least one hour before starting spacesuit operation.

After a 10-minute stay in space, during which he exercised and tumbled in front of a television camera, he returned to the cabin. He performed his feat at the end of a 16-foot tether secured to the capsule.

Upon return, the pilots returned to the normal mode of operation, breathing the near-sea-level oxygen/

Cosmonauts Col. Pavel I. Belyayev (left) and Lt. Col. Alexei Leonov on arrival at Moscow's Vnukovo Airport following their recovery 725 miles north-northeast of Moscow. Receiving their salutes are Communist Party Leader Leonid Brezhnev (left) and other high-ranking Party officials. Intended landing site was 600 miles from Moscow.

nitrogen mixture at 14.7 psi. Pressure at one point, at least, apparently exceeded this limit, going to 1.2 atmospheres.

The absence of a third man in the *Voskhod* cabin, which lofted three men into a 16-orbit flight last October 11, was attributed to the bulkiness of the pressure-suit operation and necessity for more moving about in the cabin for the experiment.

The "chief designer" of the space project, not mentioned by name, was reported in *Tass* as saying that the flight of *Voskhod II* "opens new possibilities . . . in relieving crews of orbital stations and supplying them with changeable equipment and food."

Another *Tass* report quoted Aleksandr Kuzin, a Soviet biologist, as saying that the experiment was particularly important for the construction of interplanetary space stations. "They will be assembled by the hands of a man who will have stepped out of the ship into outer space," said Kuzin.

- **New suit**—The spacesuit was a new one, created for the operation, Soviet news reports said. It apparently was covered with a white material, which a Soviet scientist said was developed by chemists to reflect the Sun's rays. Leonov carried a portable life support system on his back which supplied oxygen and purified the exhaled air.

Soviet physician Vladimir Krichasgin was reported as saying that the Soviets decided that gas pressure inside the spacesuit "should be at least 0.4 atmospheres." This pressure, almost 6 psi, would not afford a great deal of mobility, and Leonov reportedly was tired from his experience.

The Soviets seem headed toward development of a hard suit or shell-like device for extravehicular operation. One of the scientists said that "in the future the suit will give way to one-or two-seat capsules with mechanical manipulators on the outside." It also was hinted that small jet engines are being developed to propel the cosmonauts back to the space capsules after disconnecting the tether.

- **No discomfort**—Physiological information telemetered during the flight reportedly was within normal limits. At one point during the early portion of the flight, heart rates were reported at 70 and 72, and respiration 18-20 per minute. Cabin temperature at this time was 19°C, with humidity at 35%.

During the 13th orbit, telemetry gave pulse rates as "72 to 78," and respiration rate as between 18 and 20 per minute. Temperature was 18°C (64.5°F) in the cabin, with humidity at 45%.

Temperatures within the spacesuit fluctuated between 20 and 25°C. it was reported.

At a press conference after the flight, Vasily Seleznev, a biomedical specialist, discounted the danger of meteorites and cosmic rays during the flight. Chances of encountering meteorites are negligible, he indicated, for that period of time. Radiation was not considered dangeous at the altitude of *Voshkod II.*

WHAT
MATTERS MOST

to the engineer who is ambitious for professional growth and advancement, is whether the company and its projects offer the stimulus and challenge for worthwhile accomplishments. We think the creative engineer will agree that our company's broadening product range, important assignments and rapid expansion will permit him to make the most of his gray matter. These are just a few of the **CAREER POSITIONS:**

PRELIMINARY DESIGN/ADVANCED PLANNING to conduct preliminary design and program studies, prepare and present new product technical proposals in the fields of attitude control and stabilization systems. Requires familiarty with propulsion control systems. Must be able to direct and coordinate design and project support technical personnel.

PROPULSION DEVELOPMENT ENGINEER, ME or AE, to specialize in the hardware development of low thrust propellant engines and propulsion systems; devise experimental procedures to verify results of theoretical analyses and to establish performance of advanced thrust chambers and propulsion systems. Will supervise the testing, analyze and interpret results and prepare technical reports. Will participate in new product proposals.

SR. EXPERIMENTAL-ADVANCED DEVELOPMENT to conduct studies in field of space life support systems, and coordinate technical efforts of others preparing technical sales proposals; assist in planning research and feasibility programs. Interpret and translate customer requirements into practical design programs. Requires technical experience in 1 or more of the following: space life support systems or thermodynamics/heat transfer or mechanical/hydraulic/pneumatic systems. Must be able to make technical presentations to management and customers.

COMBUSTION ANALYST-PROPULSION ENGINEER, BSME or BS Chemical Engineering with experience in development of solid or liquid rocket engine field that has involved specialization in combustion processes and propellant evaluation of thrust chambers for gas generator or secondary propulsion system. Will be required to participate in development of injectors and combustion chambers for monopropellant and hypergolic bipropellant thrust chambers.

This is just a partial listing. There are many other positions for engineers at all levels of experience.

PLEASE FORWARD YOUR RESUME, including present salary, to Mr. A. J. Fehlber, Personnel Department, Hamilton Standard, Windsor Locks, Conn.—an equal opportunity employer.

Hamilton Standard

U
DIVISION OF UNITED AIRCRAFT CORP
A

Apollo Crater Landing Seen Possible

Ranger IX closes program with live transmission of photos appearing to show areas between craters as smooth as maria

by Willard E. Wilks

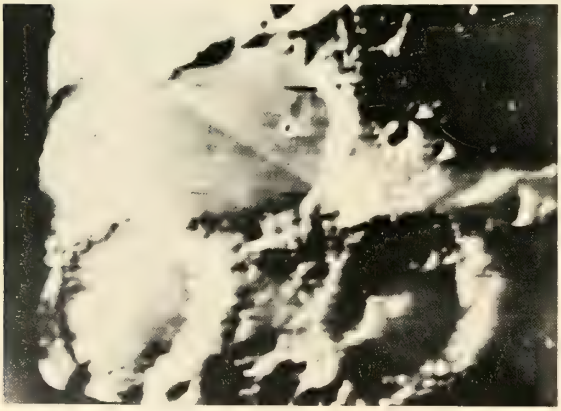
RANGER IX PHOTOS have revealed what some observers regard as significant support for the theory that volcanic activity has helped form the lunar surface.

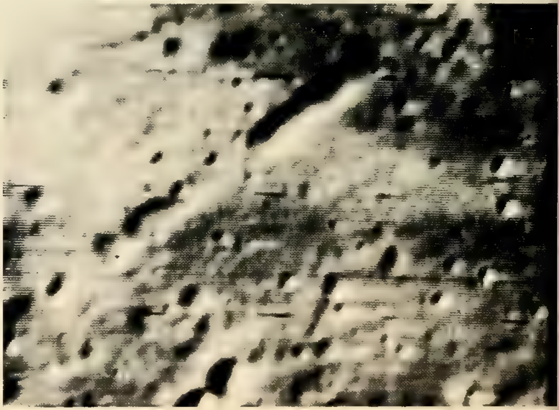
At the same time, preliminary indication from the photographs was that a *Surveyor* or *Apollo* landing probably would be possible within a large lunar crater to enable collection of a much greater variety of information than would be available on a flat *mare.* This is from the standpoint of available smooth areas.

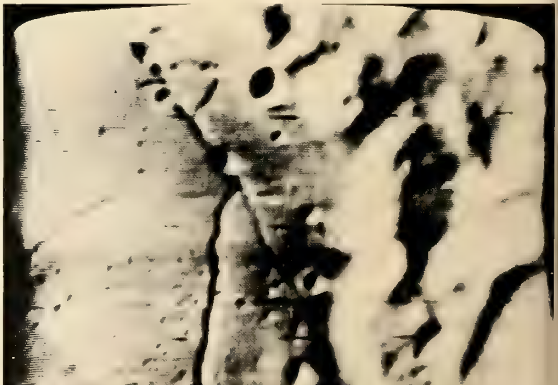
While NASA spokesmen were making no predictions about the possibilities of any crater landing attempt—and it certainly would not be considered for an early mission—Jet Propulsion Laboratory scientists were struck by the fact that the first photos taken inside a lunar crater revealed some areas that appeared smooth enough for a landing.

In photographs taken within the crater Alphonsus by *Ranger IX's* B camera, the crater floor appeared to have a greater density of small craters in some areas than the mare site photographed by *Ranger VIII.* But there appeared to be substantial areas between craters, rills and large depressed spots that were generally as smooth as terrain seen in *Ranger VII* and *VIII* photos.

At the same time, photos obtained with the A camera revealed an area in the northeast portion of Alphonsus that had a very high density of small craters. This camera scanned along a path running northeast across the central ridge and peak in Alphonsus. On both sides of the ridge and extending down onto the floor of Alphonsus on the northeast side of the







TOP LEFT: Photo taken by Ranger IX 1,300 miles above Moon shows crater Alphonsus (lower left), as well as craters Ptolemaeus (top) and Albategnius (right). Spacecraft impacted within four miles of target area in Alphonsus. TOP RIGHT: Later picture taken as Ranger drew nearer lunar surface. Final spacecraft in program presented Jet Propulsion Laboratory scientists with their first opportunity to show photos from Ranger prior to impact. RIGHT: Ninth from last picture relayed live to Earth before landing. Quality of these photos is diminished due to wire transmission. Resolution of original photos was vastly superior.

Kidde puts hydrogen peroxide to work.

When Syncom needs a kick in the apogee to keep precisely on its station, a Kidde hydrogen peroxide secondary propulsion system does it.

Kidde reaction control systems are standard equipment aboard more than 50 vehicles which have been launched into space—more than any other contractor. Kidde contracts include Asset, ATS, Early Bird, Little Joe, Lunar Landing Simulator, Modular Maneuvering Unit, Satar, Scout and Syncom.

Why Kidde? Because Kidde and Company has become the number one name in the precision control, storage and utilization of gases—in space or on the ground.

For complete secondary propulsion systems or extreme-temperature gas handling components—for better ways to put gases to work—call on Kidde. Write for free booklet, "Kidde Spacecraft Flight Control Systems" and full color wall chart, "Optimum Regimes for Reaction Control Systems." Walter Kidde & Company, Inc., 320 Main Street, Belleville, N. J. 07109; Northolt, England; Luneburg, Germany.

Kidde

Circle No. 72 on Subscriber Service Card

FULLY AUTOMATIC

9052 A33
9077 A33

THEODOLITE FILM READING

Now aircraft and missile tracking pictures taken by cinetheodolites on 16mm, 35mm, or 70mm film can be automatically "read" and analyzed by means of a Programmable Film Reader system developed by Information International, Inc.

Any desired data or measurements may be automatically extracted by means of appropriate film reading programs which may be written to direct and monitor the film scanning process. Alphanumeric, digital or dial encodings on the film may also be read.

The Programmable Film Reader system is a means for rapidly reducing large quantities of photographic data at processing rates far exceeding those of semi-automatic systems utilizing a human operator. The system "recognizes what it sees"; only the data of interest is extracted. No further computer processing is necessary to obtain this data. Data output is in digital form on IBM-compatible magnetic tape.

Other applications include the automatic reduction of radar A-scope film; spark and bubble chamber film; oceanographic current meter and bathythermograph film; and medical film. The firm supplies services for reading and digitizing film sent to it for processing. A brochure describing the film reader and film reading systems we have developed is available on request.

INFORMATION
INTERNATIONAL
INCORPORATED
200 6th STREET
CAMBRIDGE, MASS. 02142

ridge, the area shown was riddled with small craters.

- **Food for volcanist**—Some investigators considered this to be fair indication that Alphonsus was indeed a seat of volcanic activity. Support for this view was seen in the fact that small craters also appeared along the top of the high mountainous ridges surrounding Alphonsus in greater numbers than Earth-based pictures had shown. As proponents of the volcanic theory see it, there are too many craterlets atop the ridges for them to be considered of impact origin.

Beyond these early indications, preliminary examination of the *Ranger IX* pictures revealed no new input on surface characteristics as far as *Apollo* is concerned.

Following their first quick look at the photographs, JPL and NASA spokesmen declined to speculate on whether the surface might have a layer of dust, gravel, or lava.

However, because of the possibilities presented by the great variety of features shown in the Alphonsus pictures, it was believed that the photo evaluation team might be able to extract a great deal more information from the new photos than from those obtained earlier.

- **All this and TV, too**—*Ranger IX* returned 6,150 excellent pictures of areas surrounding and within Alphonsus shortly before impacting in the crater's northeast corner at 9:08:20.06 EST on March 24. The spacecraft impacted approximately 12.9 degrees south latitude and 2.4 degrees west longtitude following a 259,143-mi. flight in 64 hours, 31 minutes and 12 seconds.

One of the most striking aspects of the *Ranger IX* accomplishment was the photographing of such a wide variety of features inside the crater. Because of this, the pictures were expected to produce more data of general scientific interest than the total information returned by the earlier *Rangers*.

At the same time, the photos were rated the best in the *Ranger* program largely because a terminal maneuver—first ever made in the program—virtually eliminated image motion from pictures obtained by the P cameras.

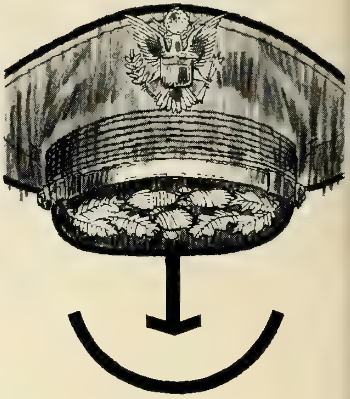
While accomplishing an outstanding success, JPL also achieved the first real-time commercial telecast of *Ranger* photos with equipment that was installed in the Pasadena, Calif., facility at almost the last minute.

- **Photo analysis goals**—Evidence scientists will seek to find in the new pictures includes disposition, size and

CAPITAL . . Film Problem-Solver to the Aerospace Industry

How to keep the AIR FORCE HAPPY...

(...and the Army and the Navy and any of your other clients)



Be ON TIME to make your motion picture presentation . . . by making use of Capital Film's "one stop" ultra-modern laboratory facility.

Use your "in-house" photographic staff to film your product, system or capability . . . then let us take it from there. We will supply professional editing, sound/narration and laboratory services.

RESULT: A professional presentation film—on schedule. We are geared for quality and speed.

For production of your next film presentation, call on Capital Film Laboratories.

CAPITAL
FILM LABORATORIES, INCORPORATED
470 E Street, S.W. Washington, D.C. 20024
Phone: (202) DIstrict 7-1717 Cable: CAPFILM

Write for FREE brochure on Capital's services and a list of aerospace customers.

texture of material in and around the main crater; whether the crater edge and walls reveal a cross-section showing discernible strata indicating whether the Moon has different surface layers and materials configuration of the crater edge and walls; whether the inside crater walls and the floor show signs of lava flow; whether the floor appears the same as maria sections photographed to date; slumping of walls and cracking of the crater floor.

Indication of lava flow could support a theory advanced by Dr. Gerard Kuiper of the University of Arizona, chief evaluator of the photos. He has suggested that the maria, if they are lava flows, would contain subsidence areas of drainage craters which present a very hazardous landing surface despite a smooth appearance.

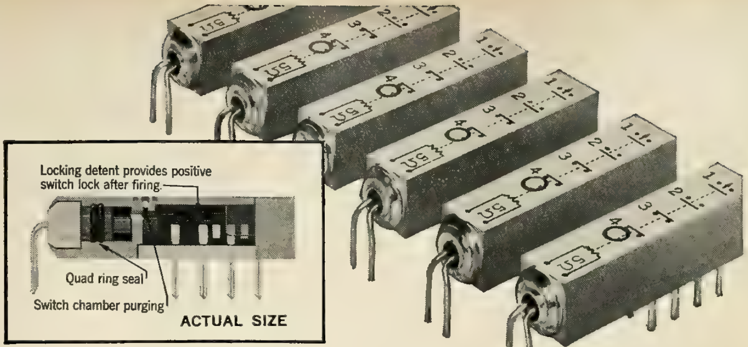
Scientists had hoped the first closeup photos of the structural details of a large lunar crater might enable the first major comparison of lunar features with similar structures available on Earth, including craters created both by meteoric impact and volcanic activity.

The photos also will be compared with enlargements of the best available Earth-based pictures of the same area. Two well-known Earth-based pictures of Alphonsus show what may be a gaseous discharge from the crater.

- **Gas detection doubtful**—It was considered extremely unlikely, however, that the *Ranger IX* photos would reveal evidence of gaseous emission, since the cameras were not equipped with the necessary filters and the "discharge" is sporadic.
- **Flight details**—Following the mid-course maneuver March 23, JPL estimated the spacecraft would impact in the northeastern portion of Alphonsus at 2.3 degrees west selenocentric longitude, 12.9 degrees south latitude, somewhat northeast of the central peak. This estimate was only four miles from the selected point, which was 0.25 degree west, 13 degrees south.

Impact followed a nearly textbook flight from the March 21 launch. Midcourse maneuver was called the best ever.

Dr. William Pickering, JPL director, said that since the two previous *Rangers* had obtained photos of smooth maria—Cognitum and Tranquillitatis—for comparative purposes, the crater was selected for the last *Ranger* mission to show different features. The new photos could contribute to knowledge of the lunar model as a whole in addition to providing data directly useful to the *Apollo* program.

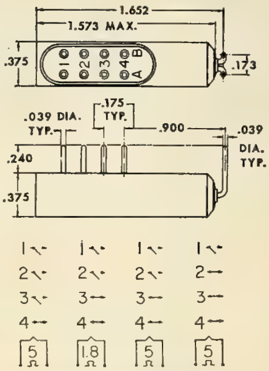


highest reliability

Model 1785

Squib-Actuated Multipole Switches

Model 1785 squib-actuated multipole switch provides highest reliability for aerospace/missile applications. Currently operational on a major missile program, it offers advantages found in no other similar type switch. Exclusive Raymond features include a quad ring which seals firing chamber from switch chamber, plus switch chamber purging, and positive switch lock after firing to 20,000 "g's" shock. These features eliminate the most common chronic ills of relay squib switches such as poor contact resistance after firing and contact chatter during shock and vibration. Lightweight, small in size, rapid in action, the Model 1785 is a hermetically sealed four-pole switch, available in any combination of open or closed switches with 5-ohm or 1.8 ohm bridge resistance wire. Requirements in excess of four circuits can be accomplished by ganging units. Switch actuation is accomplished in 10 milliseconds max. by electric ignition of a small explosive charge. 5 VDC for 2 milliseconds is required for all fire. Operates under following environments: Temperature: −65° to +165°. Vibration: 10 to 2000 cps @ 10 "g". Weight: 25 grams max.



OTHER RAYMOND SQUIB DEVICES

Model 1527

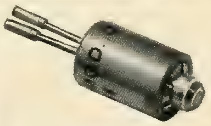
Miniature Multiple Switch Unit. Four SPDT micro-switches dimple motor actuated. Not a one-shot switch. Dimple motors easily replaceable for reuse. Compact, approximately 1 ⅛'' x 1'' x .75''. Weight: 31 grams.

Model 1874

High Current Squib-Actuated Switch. Will carry up to 100 amperes. Small size, high reliability. Resists contact chatter through 1000 "g" — 2 milliseconds shock, and 2000 cps @ 10 "g" in three planes vibration. Weight: including terminal screws, 0.88 oz. Size: .438" dia. x 2.170".

Model 1186

Super-fast sub-miniature squib-actuated single pole switch. Actuates within 150 micro-seconds. 2-circuit transfer switch convertible to SPDT or SPST. Weight: 4.5 grams. Size: .380" dia. x .728" less lead.



Model 1798

Squib-Actuated Piston. Low current impulse provides powerful mechanical motion. Has plug-in feature. Piston travels .125" with 20 lb. force. Requires 5 amperes for 2 milliseconds to fire. Weight: 7 grams. Size: .375" dia. x .591".

Write for complete specifications, or consult your nearest Raymond representative.

Raymond

CAPABILITY
RELIABILITY

RAYMOND ENGINEERING LABORATORY, Inc., 1011 Smith Street, Middletown, Conn.

Circle No. 82 on Subscriber Service Card

Proposed Optical Satellite Described

by Michael Getler

NEW YORK—First details of possible configurations of NASA's *Optical Technology Satellite* (*OTS*) and experiments to go aboard it were revealed by scientists from Marshall Space Flight Center at the International Convention of the Institute of Electrical and Electronics Engineers here last week.

OTS, which is still in a feasibility study phase, would place a satellite in orbit to serve as a test-bed for a variety of systems needed for long-range space communications and astronomical observation. Although not yet an approved NASA program, it has already been funded at the study level.

Major work has been done by Perkin-Elmer Corp., under MSFC contract, and additional inputs have come from Grumman Aircraft and Douglas Aircraft. Further awards for preliminary design of some experiments are expected within the next few weeks.

With program approval, major funding could begin in Fiscal Year 1967. Industry sources have estimated costs per satellite ranging up to $50 million, depending upon final configuration. (Reports of the likelihood of the new project were carried in M/R, June 1, 1964, p. 30, and Nov. 30, p. 101.)

- **The outlines**—NASA's report to IEEE was based on results of Perkin-Elmer's work to date.

As currently envisioned, *OTS* would weigh 6,000-8,000 lbs., be about 20 ft. long and 13 ft. in diameter, require a three-year development time, demand less than 1 kw of onboard power, and be designed for a lifetime of 1-2 years. It would be placed in a synchronous orbit, probably circular, with an orbital plane inclined 30-60 degrees from the Equator, using a *Saturn IB/Centaur* launch vehicle.

The satellite would have four major objectives: development of a two-way optical communications link for deep-space missions; determination of the effects of the space environment on large, diffraction-limited optics (30-in. or larger) to allow eventual development of 100-200-in. spaceborne telescopes; determination of environment effects upon various optical systems—such as thermal problems, vibration, isolation, material deterioration, and atmospheric effects on transmission; and lastly, a group of secondary experiments, e.g. measurement of the spectral intensity of Earth-reflected sunlight.

- **Communications**—Thus far, 14 experiments have been chosen to simulate deep-space communications conditions for ranges to 100 million mi. These include: atmospheric scintillation effects on coherent beams, atmospheric effects of plane and circularly polarized light, remote manual optical alignment, optical heterodyne alignment at satellite and ground station, demonstration of tracking to 0.1 arc sec in the satellite, point-ahead or lead-angle tracking, space-to-ground-to-space loop closure, demonstration of tracking in the presence of satellite motion, telescope suspension system comparisons, ground station tracking transfer, Earthshine effects of acquisition and track, demonstration of a communications system with a 10-mc bandwidth using several modulation schemes, and onboard evaluation of environmental effects on large diffraction-limited optics.

Discussing some of these experiments in more detail, Dr. J. L. Randall of MSFC said that for the two-way communications link, both the satellite and ground stations would have laser beacon and tracking systems. In one possible *OTS* configuration, two telescopes would be utilized, with one a relatively simple device to

Block Engineering, Inc.

REDEYE
GEMINI
CBW
BLUEGILL
ASW
SATAR
MINUTEMAN
LUNAR SOILS
CELESTIAL MAPPING
PRESS
GLOW
TABSTONE
DISCOVERER
ATLAS
(to name a few)

Block's electro-optical capabilities and instrumentation have contributed to all of these programs.

Are we contributing to yours?

19 Blackstone Street • Cambridge, Mass. 02139

Circle No. 83 on Subscriber Service Card

Let us put these new ADVANCED Graphite Grades to work for you

Exciting possibilities in design engineering are opened by our "advanced" carbon and graphite grades with their unique characteristics. Their physical properties may suggest improvements or new applications in your field—if so, call on us. We'll be glad to give you samples, full information, and technical assistance.

GRAPHITE GRADES H205 and H205-85: These grades are fine grained, extremely strong graphites, exceptionally stable under high temperature radiation. They are finding wide use in nuclear, aerospace, and metallurgical applications. They make excellent dies for non-ferrous continuous casting.

GRAPHITE GRADES JOZ AND JOZ-254: Very fine grained, uniform graphites engineered to be strong and virtually isotropic. Irradiation tests at high temperatures find that they too are highly stable.

GRAPHITE GRADE H204 AND CARBON GRADE B204: Both are unique in possessing high strength-to-weight ratios at extremely low densities. A uniform, controlled cellular porosity gives these grades low K-factors.

GRADE		H205	H205-85	JOZ	JOZ-254	B204*	H204
STANDARD SIZES DIAMETER x LENGTH (in.)		10 x 12 10½ x 18 and 16½ x 24	17 x 14 9 x 20 x 24	8 x 12 and 5 x 48		15 x 15 16 x 16 x 16	
Maximum grain size (in.)		.006	.006	.004	.004	.008	.008
Bulk Density Apparent Density (g/cc)		1.75	1.81	1.73	1.83	0.75	0.75
CTE 20-100°C (in/in/°C x 10^{+7})	WG	40	41	45	47	38	30
	AG	51	50	50	53	40	35
Young's Modulus Sonic Method (psi x 10^{-6})	WG	1.6	1.7	1.4	1.5	0.5	0.2
	AG	1.4	1.5	1.4	1.4	0.4	0.2
Tensile Strength (psi)	WG	3200	3500	3200	3800	500	200
	AG	2800	3000	3000	3500	600	200
Modulus of Rupture Flexural/Strength (psi)	WG	4500	4700	3800	4500	1100	600
	AG	4000	4300	3700	4400	900	500
Compressive Strength (psi)	WG	8500	10000	8000	9500	3000	1000
	AG	10000	12000	8200	10000	2800	1200
Electrical Resistivity (ohm-in. x 10^{+5})	WG	50	40	50	46	1300	200
	AG	55	44	55	53	1450	250
Thermal Conductivity (BTU/hr/ft^2/ft/ft/°F)	WG	85	90	75	80	0.4	2.5
		80	85	72	76		
Brinell Hardness		15.0	18	12.0	13		
Permeability D Arcy	WG	.02	.006	.01	.005	.25	.20
	AG	.004	.001	.005	.003	.20	.05

WG Test specimens cut with their long dimension with the grain.
AG Test specimens cut with their long dimension against the grain.

*Not graphitized

PRODUCTS YOU CAN TRUST
GRAPHITE PRODUCTS
GLC
DIVISION

GREAT LAKES CARBON CORPORATION
18 East 48th Street • New York, N.Y. 10017
OFFICES AND AGENTS IN PRINCIPAL CITIES AROUND THE WORLD

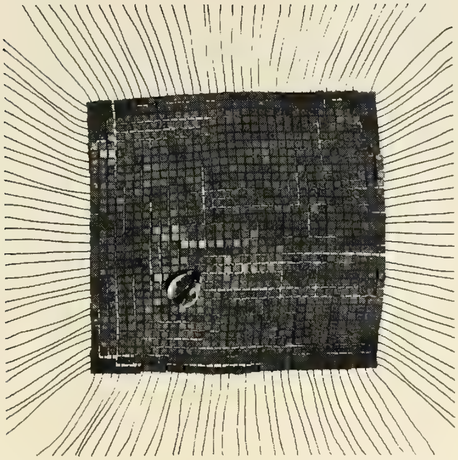
Great Lakes Carbon Corporation is one of the world's largest manufacturers of graphite for electrothermic and electro-chemical processes—and for aerospace, nuclear, metallurgical and other industrial uses.

Circle No. 45 on Subscriber Service Card

You can pack more than 2000 bits per cubic inch into a MicroBIAX array.

If you're designing ground or space borne data systems, contact Ken Kinkopf at Raytheon Computer. Phone: (714) 546-7160.

He'll send you a sample element.



1156 BIT TWO-WIRE MICROBIAX LOOM

This remarkable bit-density is made possible by the new MicroBIAX memory element, a tiny ferrite multi-aperture core less than 0.050 inch high — approximately one fifth the size of the standard BIAX unit. MicroBIAX is designed specifically for two-wire memory systems. It so simplifies the array wiring scheme that your system costs less, is far more reliable.

MicroBIAX gives true non-destructive readout at 2 megacycle rates, with readout at up to 10 megacycles in custom systems.

MicroBIAX operates throughout a —55°C to +100°C temperature range at low power levels.

Standard products from Raytheon Computer's BIAX and MicroBIAX line make up the world's fastest special-purpose memories.

For complete details and specifications on memory systems, arrays and elements, write for Data File B-105P. Raytheon Computer, 2700 S. Fairview Street, Santa Ana, California 92704. RAYTHEON

Circle No. 85 on Subscriber Service Card

perform the basic acquisition, tracking to 0.1 arc sec, and large-bandwidth ground station communication. The other scope would be more complex and be used for the point ahead experiments, tracking transfer, optical heterodyning and test of various lasers and modulators.

To achieve the 0.1-arc sec tracking and transmit of laser beams, NASA is looking at approaches using common optics for coarse and fine tracking and transmitting rather than separate tracking and transmitting telescopes. One possibility is a version of the *Stratoscope II* technique, substituting an image dissector tube to limit field-of-view problems. However, a better approach at this point appears to be a modified Cassegrain device, the Ritchey-Chretien system, which is shorter and has good off-axis properties.

Among the problems with this approach that NASA is concerned about is isolation of the high-power laser transmitter from lower-power operation with the receiver detector. Also, how well can a laser transmitter be boresighted to the tracking optics after launch vibration, and what amount of angular modulation will be induced on the transmitted laser beam by the optical modulator?

For the acquisition and tracking experiments, the ground station beacon is likely to be an Argon laser operating at 4880 or 5145 Ang. with a 10-100 watt power output. Tests are planned to check ability to locate the ground beacon directly using a 1-deg. search field during various conditions and the ability to remain locked at various transmitted power levels and Earthshine conditions.

- **Key point**—The most critical capability for deep space laser communications involves the point-ahead, or lead-angle, requirement due to the transverse velocity of the space and ground stations relative to each other. The lead angle for a two-way link, says Randall, is about 2 arc sec per 1 mile/sec transverse velocity, which comes out to lead angles of about 36 secs for some deep space missions. Spacecraft translational velocity increases might also affect this.

Computation of the proper lead angle could be done on Earth or on-board the spacecraft, NASA reports, because of the known geometries of the two stations from tracking data. The accuracy of this lead angle, however, must be within the transmitted beamwidth in order to hit the ground beacon. Randall believes the transfer lens used in the proposed fine tracking system is capable of this.

In and out.

Think of today's combat tactics.

Missiles equipped with nuclear warheads. Divisions dispersed over a 25-mile area. Forward edge of battle (FEBA) in constant flux. Calling for more fire support.

Committed to action: the short-range Little John missile system. Time to displace forward. In moments, it's loaded aboard a CH-47A Chinook helicopter—and the Chinook lifts away and heads for the front. Moves in. Lands. Unloads. An artillery team goes into action.

But the Chinook doesn't wait. It moves out. Back to the rear to pick up more firepower.

In and out. In and out. Delivering not only the Little John, but components of the Pershing missile system, vehicles like the Gama Goat—or a combat platoon. A full 6-ton payload.

Operating with units of the 11th Air Assault Division, the Chinook is today the U. S. Army's standard medium assault helicopter. A performance tested reality—made possible by the U.S. Army's foresight, guidance, and support, joined with the resources, management, and technical capabilities of the Boeing Company.

BOEING
VERTOL DIVISION
MORTON PENNSYLVANIA

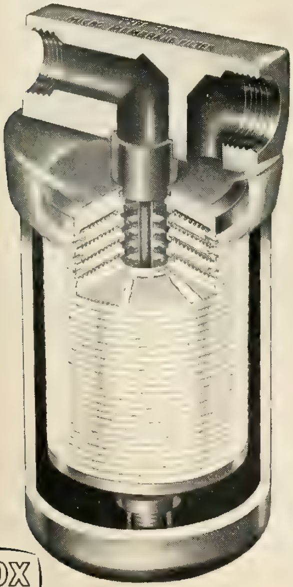
Circle No. 73 on Subscriber Service Card

FILTERS MICRONS & TIME

Why *time?*

. . . because with the *new* COX MICRO MEMBRANE filter, you will find it takes *far less* time to clean up a system than it does with other filters *of equivalent rating.* Like 1/10th the time. Thanks to efficient *depth filtration* and the tremendous *effective area* of MICRO MEMBRANE filters.

Many aerospace users are amazed at the results when they switch to MICRO MEMBRANE filters for cleaning solvents, fuels, oxidizers, oil, and other fluids. If you are concerned with filtering aerospace fluids—we've got data you'll find interesting. Just drop us a note . . . call . . . or use the magazine inquiry card. COX INSTRUMENTS DIVISION/Lynch Corporation, 15300 Fullerton Avenue, Detroit, Michigan 48227. Phone (313) 838-5780.



COX INSTRUMENTS

COX INSTRUMENTS DIVISION / Lynch Corporation

MANUFACTURERS OF COX INSTRUMENTS, NANKERVIS TEST EQUIPMENT, AEROSPACE SUPPORT SYSTEMS, CONTAMINATION CONTROL EQUIPMENT, WASTE TREATMENT EQUIPMENT

Phoenix To Give Navy New Air-to-Air Muscle

by Donald L. Zylstra

NAVY'S *PHOENIX* air-to-air missile system, now in the midst of a highly classified development program, "will have far greater range and attack capability than any air-to-air system now operational," according to its designers.

Many officials in the Directorate of Defense Research and Engineering, and other informed observers, privately believe that the Air Force version of the F-111 will eventually also be equipped with the weapon—because of the lags and uncertainties in the development of a missile for the F-111A.

Phoenix (XAIM-54A) "represents a significant technical step ahead" over all other systems now contemplated and has a "multiple-shot capability," informed sources say. In addition to being launched from a total of six wing hard points on the F-111B, the weapons will be carried in the aircraft's weapons bay. Normal operational procedure apparently will call for simultaneous launch from the six wing locations—presumably ruling out infrared techniques for terminal-homing guidance of the missile, since a salvo of six would be launched against disparate air targets.

The Navy's new missile is described as being air-launched by "an advanced radar and missile control system capable of 'seeing' enemy aircraft through any kind of weather, day or night." Its mission is to provide air superiority over beachhead operations as well as dispersed fleet units. The radar will be able to lock on an enemy aircraft and launch the missile. The missile's own homing guidance system will then take over and steer it to the target.

The airborne missile control system associated with *Phoenix* in the F-111A is designated AN/AWG-9 and the missile/bomb launcher, MAU-48A. The control system in the aircraft is equipped with two target sensors—a radar and an infrared search and track set. Data from both sensors are processed by a solid-state, high-speed general-purpose digital airborne computer.

Output is visible to the missile control officer on two displays, a 10-in. cathode ray tube unit and another with a 5-in. multi-mode storage tube. The antenna is described as "the largest broad-band circular antenna ever built." It has a high aperture efficiency that results in increased range.

The missile itself is powered by a solid-propellant rocket motor and equipped with both semi-active and active guidance. *Phoenix* is assembled in sections, making it possible to handle a complete unit or to break it down for shipboard handling.

● **Pacing system**—Navy research and development officials describe the airborne missile control system as definitely the "pacing item for ultimate deployment" of the F-111B with the fleet. Because it is designed for use in a faster aircraft than the *Eagle* missile component of the abondoned *Eagle*/Missileer system, *Phoenix* will offer an entirely different type of capability—providing both on-station and "deck-scramble" offensive features not hitherto available in an aircraft-missile system.

Hughes Aircraft Co. is the prime contractor for *Phoenix*, for the missile itself and for the airborne missile control system and its associated special support equipment. Litton Systems is the major subcontractor for the computer, controls and displays and Rocketdyne is the subcontractor for the rocket engine.

The missile system development effort is currently in the midst of what Navy acknowledges to be something of a stretchout, because additional unplanned R&D expenditures have been occasioned by the decision to redesign the rocket motor and case. But this extra R&D expense should be more than compensated in terms of later production savings resulting from simplified fabrication

← Circle No. 86 on Subscriber Service Card

HYPERVELOCITY IMPACT STUDIES

Impact flash photo

Crater formed by slender rod impacting at 17500 f.p.s.

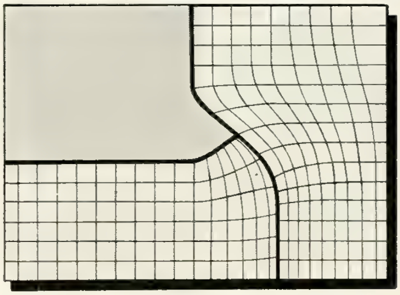
The aerophysics research laboratories of Computing Devices of Canada Limited offer extensive facilities for experimental and theoretical investigation of hypervelocity impact.

Flash X-ray, image intensifier cameras, radiometers, and spectographs measure hypervelocity impact phenomena of ½″ particles launched at 30,000 feet per second and 1-½″ particles at 20,000 feet per second.

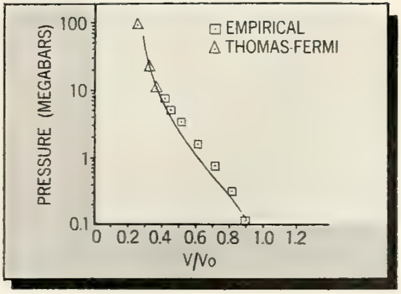
The light gas guns and other equipments used for hypervelocity launching were designed by Computing Devices.

The Company's Control Data Corporation G-20 Computer is used for solving problems in solid state physics, radiation physics and hydrodynamics.

The experienced staff and extensive facilities of Computing Devices' Aerophysics Research Department are available to Government and industrial agencies. For complete information please write to the address below.



Hydrodynamic computation of impact process



Equation of state

Computing Devices
OF CANADA LIMITED
P. O. BOX 508 • OTTAWA 4 • CANADA
AN AFFILIATE OF THE BENDIX CORPORATION

C64-6

Circle No. 1 on Subscriber Service Card

We gave this Phantom

"Side Looking" Hi Res. Radar . . . this Goodyear Aerospace Corporation development represents a major advance! Airborne radar systems are no longer restricted by antenna size limitations and can provide extremely high resolution.

Result? Revolutionary advances in reconnaissance . . . the ability to radar-map with unvarying, near-photographic clarity . . . to see through weather, day or night.

Goodyear Aerospace is currently producing its High Resolution Radar system for the United States Air Force RF4C and United States Marine RF4B, a Mach 2 reconnaissance aircraft being built by McDonnell Aircraft. Our aerospace capabilities don't stop with this radar. We have experience in missile system management, astronautics, ground support subsystems, flight and tactics simulators, correlation guidance devices, radar

U.S. AIR FORCE

II "all-weather" eyes

and communication structures, aircraft and missile plastics including radomes and canopies, and more...

With plants in Akron, Ohio, and Litchfield Park, Arizona, and our broad spectrum of capabilities, Goodyear Aerospace is uniquely qualified to further any aerospace project. For a presentation of our capabilities, write on company letterhead to Goodyear Aerospace Corporation, Box 910-PC, Akron, Ohio 44315.

PROVEN CAPABILITY: Electronic Systems

GOODYEAR
AEROSPACE

Circle No. 2 on Subscriber Service Card

from ballista to ballistic missile guidance

The ballista is one of the more ancient mechanical missile launchers. These launchers were capable of hurling javelins, beams or stones weighing as much as ninety pounds a distance of 400 yards. Accuracy was limited by the lack of projectile uniformity, and new target selection required complete repositioning.

Through many technological achievements, accuracy, range and payload of modern ballistic missiles have greatly improved due in part to the pioneering of AC Spark Plug. During the past fifteen years, AC has developed and produced inertial guidance systems for the Thor, Titan II, Mace-B and Regulus II missiles. In addition, AC is providing the guidance/navigation system for the Apollo Command Module and LEM, and the guidance system for the Titan III space booster. In avionics, AC's experience has included development of the B-52C & D Bombing Navigation System and, currently, an Inertial Navigation System for attack aircraft. For more information, contact Director of Sales-Engineering, AC Spark Plug Division, General Motors Corporation, Milwaukee, Wisconsin, 53201.

AC

MASTER NAVIGATORS THROUGH TIME AND SPACE

GUIDANCE AND NAVIGATION FOR SPACECRAFT • MISSILES • SPACE BOOSTERS • AVIONICS • DELIVERED ON TIME AT LOW COST WITH OUTSTANDING ACCURACY AND RELIABILITY

Circle No 3 on Subscriber Service Card

part I

tactical warfare and technology

The requirements in tactical warfare are much the same as they were in the time of Alexander the Great—to move, to engage and destroy the enemy, and to communicate. But the approach to these traditional functions today has an important new dimension. The resources of the Space Age now are at the command of the foot soldier who must find, fix and finish the enemy. In this special issue, compiled with the full cooperation of the Department of Defense, *Missiles and Rockets* surveys the impact of advanced technology on tactical warfare—an impact which will be felt, not only throughout the industry, but on combat forces from Viet Nam to Western Europe.

Part I deals with the overall philosophy and the problems inherent in applying advanced technology to tactical warfare.

Part II examines the known technologies which have application to these problems.

Part III surveys programs under development, their virtues and shortcomings, and attempts to point a way to the future.

MISSILES AND ROCKETS VOLUME 16, NUMBER 13 MARCH 29, 1965

Myriad R&D Problems Await Solution

Defense officials cite urgent difficulties in virtually all areas of limited warfare; industry faces growing market—and responsibility

RESEARCH AND DEVELOPMENT for limited warfare is just beginning—despite the fact that more than $2 billion has been spent over the last three fiscal years for tactical R&D. This is the message Defense officials want to get across to industry.

In only one area—air-to-air weapons—are they ready to admit that the situation is in hand. In all other categories—air-to-ground, ground-to-air, ground-to-ground, sea-to-ground, sea-to-air and air-to-sea—there are problems desperately looking for solutions. In all these categories of employment are difficulties with target acquisition, self-location, environment, firepower effectiveness, communications security and command and control.

This is one of the facts DOD is trying to make clear—there are a myriad of tactical warfare puzzles that must be resolved. Another basic fact—age-old, but probably further from realization today than in the days of muzzle-loading weapons—is that tactical weapons must be simple.

It is difficult to be simple—in fact, it requires a reverse type of engineering not common to companies used to dealing with advanced technology. The most commonly heard complaint about weapons now in the inventory or under development is that they have been over-engineered and are difficult to keep in service and ready to fight. Simple solutions must be imaginative, and lack of imagination has thus far been the most common failing of industry. Weapons design has tended to follow conventional engineering practice and engineers have tried to build weapons that would be all things to all men.

• **Case in point**—*Mauler* is an example, although the Army must be assigned much of the blame for the failure of this air defense system.

Mauler was designed to counter a range of targets—from slow-moving aircraft at low altitudes, through high-performance all-weather aircraft to tactical battlefield missiles launched in high-density raids. The system to counter this spectrum of attack had to be mounted on one vehicle and had to be able to shoot while either moving or floating.

This was the biggest "single mistake," according to Defense officials. They say the Army "tried to do too much at one crack and the program was too adventurous." "*Mauler* was a good concept," they say, "if it had been put on two vehicles and not called upon to fire when moving or floating. It is the best argument in the world for Program Definition."

What happened to *Mauler* is well known. It encountered serious technical difficulties, largely because of the high density of component packaging on the single vehicle, and the costs of development and deployment soared. A feasibility validation program was ordered and has been under way for more than a year.

Final recommendations on *Mauler* are expected to be submitted to DOD by June 1.

However, the disposition of *Mauler* appears to be already decided. The program will be reoriented, put on a longer time scale and designed as a less sophisticated weapon. Whether it will continue to be called *Mauler* and whether the same contractors will be involved will depend on the Army recommendations.

Whatever happens, there will be less emphasis on all-weather capability in the forward area, since weather can interfere with not only aircraft but missiles as well. The U.S. has only one all-weather aircraft, the A-6, and missiles have to be targeted—which in periods of low visibility is difficult. It can be assumed that the enemy has the same problems.

Lessons learned from *Mauler* are that the threat must be evaluated realistically, both from a technical and cost/effectiveness standpoint, engineering solution must be simplified, and the total battlefield environment must be taken into consideration.

• **Very real problems**—Air defense is an area affecting all the services. The U.S. simply does not have a satisfactory capability. Consequently, this is the effort to which resources are being commited most immediately. In addition to *Mauler*, the Army is pursuing *Redeye* *Chaparral* and *SAM-D* (*Surface to Air Missile Development*). A boosted *Redeye* is also being looked at (see air defense story, p. 101).

One question now being raised is whether a battlefield missile defense system must also be an air defense system. At this point, there is no simple answer.

In any case, guns are to play a role from now on in Army air defense systems. In fact, a DDR&E spokesman sees a "big gain in effectiveness in going back to guns. We will always find guns in air defense in the future." The decision to buy the Hispano-Suiza from the Germans, in spite of U.S. gold flow problems and the fact that it is an old (1950) weapon, was dictated by the immediacy of the problem. Three suitable gun systems are under development, but none of them will be available for at least three years.

Both experience in Viet Nam and independent Army studies of gun systems have shown the effectiveness of guns against even high-performance aircraft. In fact, the results correlate to an amazing degree. With only radar ranging, the AA gun is a cost/effective weapon.

Industry might well keep in mind the fact that the U.S. lost five high-performance aircraft to machine-gun fire in a raid on North Viet Nam March 2. And the Communists have been very successful in Laos with manually-trained, optically-tracked 37 mm. guns.

In the Navy, major emphasis is centered on the Point Defense system and the *Advanced Surface Missile System (ASMS)*. Competition for the latter is intense—seven companies are vying for the contract.

The winning company, however, will be the one which has chosen the ship to go with the weapon. This ship must also be able to go onto other missions such as ASW and fire support without wasted time. And it must be able to keep up with the fleet. The missile itself must be capable of employment in surface roles as well as air defense.

MAULER IS PRIME EXAMPLE of too big a technical step at one time, in terms of a system designed to meet a poorly formulated threat. Program is to be reoriented to less sophisticated weapon after Army finishes evaluation June 1.

Point Defense supposedly will be based on a ship-launched version of the *Sparrow-III* or on a less sophisticated version of the *ASMS*. However, this is in the early pre-definition stages; the possibility of guns should not be dismissed—even though the Navy feels that guns can no longer handle the increasingly difficult targets.

- **Painful challenges**—In the area of ground-to-ground weapons, the Defense Department is just facing up to the challenge.

The basic problem is how to find a target. A troop concentration occupies a large area, but how does an airplane see a tank when the plane is flying at Mach 0.8 and 500-ft. altitude? Furthermore, to use a terminal guidance scheme the weapon must know where the terminal is.

This whole area of weapons is one in which there are many more problems than solutions. In sea-to-ground weapons delivery there simply are no solutions.

When battleships were retired, the close-support mission fell to the attack carrier. There are those who feel that the CVA can do the job, but part of the overall problem is the fact that there is competition for the assignment. On the technical side, the problem is to find a weapon to take under fire pinpoint hard targets.

Air-to-sea weapons have not been examined with sufficient thought to the requirement. What is needed is a weapon which can hit the sea and continue under it to the target. At present, air-launched torpedoes, such as the Mark 46, make use of a drag parachute to slow the weapon before it hits the water.

A number of schemes could be, and to an extent are being, used for air-to-ground delivery. There are basically two kinds of systems: optical viewing, as represented by the *Walleye* family of weapons, and radiation weapons such as *Condor*. Accuracy of delivery for both categories is measured in terms of tens of feet.

Manned homing is relatively new, and the accuracy of delivery in this mode would be measured in feet. Basically, this is hinged to the tried-and-proven principle of having a forward observer direct fire on targets. Its employment is based on the combination of the air delivery with the ground observation.

A problem in the past has been that the Army tends to think along stereotyped lines. The Air Force works with equally rigid concepts. But a combination of the airplane to deliver the weapon and the forward observer to direct it to the target—through some command link or through illuminating it with perhaps a laser—could be an effective combination.

- **Key issue**—At present, the most pressing problem for all services is target acquisition. Whether the assignment is antitank operations or locating and destroying enemy troop units, the problem of "where is the target" looms up. Much progress has been made but there is still room for creative ideas. This is why the budget for reconnaissance equipment has gone up in FY '66.

"We hope industry can develop an effective airborne track-while-scan radar that can be used for land surveillance as well as air targets," a DOD official told an industry briefing. "Target acquisition and target handling, involving the identification as well as location of the enemy, has been a major problem and promises to get no easier in the future. It may be that the answer lies in the integration of multi-sensor information and the use of advanced pattern recognition techniques."

In counter-insurgency, this problem looms even larger. Detecting the individual guerrilla, bands of guerrillas or even major insurgent installations is a difficulty that still defies solution. Electro-optical, infrared, and ultrasonic cameras are among many possibilities being explored. In fact, one DOD official said that he "didn't know of any area which was not being explored." However, these devices must employ technology which, while it may be sophisticated, is cheap, simple and easily maintained in use.

A second problem is one of self-location: the need for mobile forces to locate themselves in relative coordinates with very small errors. This is essential for re-supply, fire direction and command. Equally essential is the ability of the unit to do this in real time.

Coping with the environment has plagued armies since the beginning of time. In the past, this has meant overcoming terrain and weather through sheer force. Now, Defense officials feel that the environment actually can be used to the advantage of combat forces.

One example is mud. For centuries, soldiers have waded in and often become bogged down in mud. Now, the emphasis has shifted to understanding mechanics of soils and the interaction of men and equipment with the phenomenon known as mud. This type of research, still in its infancy, could yield important new ideas in equipment and tactics.

Over-land mobility is a perennial problem. The vehicle which will be able to move in all weather and over all types of terrain still has not materialized. However, the Gamma-Goat is a break with past tradition and a step toward that goal.

This is a segmented, articulated vehicle which moves with the terrain with all six wheels providing traction. The Army is planning to procure a 1¼-ton truck based on this principle. Any similar imaginative approach to mobility will receive close attention.

In the ordnance and fire control area, an official says the question is basically "once acquired, how can we engage . . . targets without exposing our own weapons launch site?"

This is especially critical to anti-tank weapons. A cardinal rule for tank commanders is that they must travel in pairs. Hence the anti-tank gunner is put at a fatal disadvantage even if he has a first-round hit, since the recoil of his weapon reveals his position.

It is even worse when the gunner must keep the missile on target for 10 seconds.

Simple, rugged, reliable anti-tank weapons for the infantry have been firm requirements for some time. Work has been done on terminal homing systems and it may be that a terminal homing weapon will answer the problem. Indeed, it may be that the next ten years will see such improvement in accuracy and reliability that a major effect in tactics will occur.

Secure voice communications is a requirement still unmet after decades of work. "What we want," an official says, "is a portable voice system, secure for something in the order of 72 hours, which gives us the same flexibility and

Proposed Changes in Lal

FUNDAMENTAL QUESTIONS have been raised about the manner in which the Dept. of Defense conducts its research.

All echelons in DOD who are aware of the changes being proposed in the organizational and managerial responsibilities for research are reticent regarding the plans. This reserve extends from the major field commands through the civilian and military staff and up to Office of the Secretary of Defense (OSD) level.

Being proposed—and in some cases bitterly opposed—are changes which critics claim would loosen military, multi-echelon control of research programs. The major changes suggested are:

—Research laboratories would report higher in the chain of command. Rather than moving through several layers of subordinate commands, they might well report directly to the Assistant Secretary for Research and Development of a particular service.

—Laboratory directors would have greatly increased power to determine what problems they would research and the personnel needed.

The revolutionary nature of these ideas has led to considerable controversy. There is a consensus that some changes must be made. But there is formidable opposition to the idea of cutting labs away from the present organizational functioning. One service assistant secretary told M/R he would oppose having laboratories under his direct control. Military elements oppose this idea even more strongly than do their civilian chiefs.

Apart from this, the idea of allowing lab directors even more latitude than they have under the presently conceived independent research program meets resistance. The main fear is that this would divorce the labs from the mainstream of weapons development and move them into an atmosphere of research for research's sake. Again, one of the service assistant secretaries told M/R, "the lab director is no substitute for the program manager."

• **Navy takes lead**—All three services have studies under way examining the laboratories set up within their purview. However, the Navy has been the first to move in the direction Defense officials feel Defense laboratories must move.

Testifying before Congress, Navy assistant secretary for R&D Robert W. Morse said he had taken steps "which should result in general upgrading and better utilization of these laboratories." Among these moves were:

—Delegation of more authority and responsibility to the labs for the birth-to-death cycle of a weapon in order to increase the "already high scientific and technical vitality, provide increased 'elbow room' for the pursuit of self-generated ideas and maintain coherence of effort."

—Establishment of a new civilian position, Director of Navy Laboratories, reporting directly to Morse. This official will have Department-wide responsibility "for the optimum development and use of the Navy's laboratory resources."

—A thorough examination of administrative policies, practices and restrictions to effect "further improvement and refinement in the many facets of laboratory operations and environment."

However, this appears to be just a start on a program which will affect all defense laboratories. Because, say the proponents of change, "something important and radical needs to be done."

• **Industry example**—The basis for the suggestion that laboratories should report higher in the chain of command stems from studies of successful commercial R&D laboratories—most notably Bell Telephone Labs.

Almost without exception, these corporate labs report directly to the executive level of the company. In fact, most companies have a vice president for research who, in many cases, doubles as the lab director. Industrial laboratories, or at least the successful ones, do not function as subordinate entities within an operating division.

In the relatively few cases in which ARPA has had labs reporting directly to it, rather than contracting through the service for the lab work, the results have been superior. And this is another argument for change.

Management Stir Debate

• **Weapons effects**—The rationale favoring more initiative at the local level is based on some detailed analyses which have been made of weapons systems, particularly missiles. These have turned up some rather surprising results:

—Practically all of the advances in technology were initially funded at the local level—in many cases with what was then "bootleg" money. This is money that the lab director siphons off an approved program to do some other research he considers important. Recognition of the importance of this practice was inherent in the establishment of the Lab Director's Fund several years ago.

—Vital technology can not exist except at the local level. This bears on the freedom of the lab director to manage his programs as he sees fit. Specifically, it depends on his ability, and freedom, to recruit competent researchers and provide a suitable environment for them.

—Practically all advanced technology existant came out of a real systems need. Paradoxically, most of this technology ended up not in the system for which it had been intended but in other applications.

—Although the cliche that "invention can't be scheduled" holds true in a general way, there is remarkable consistency in the length of time between conception and the application of research. This time lag is always five to 10 years.

• **Pilot project**—One approach that might overcome opposition is to set up a pilot laboratory based on the study results to date. Essentially, this would be a pure experiment in research management. It would focus around a vital problem in R&D—for example, counterinsurgency—and attempt to prove by its greater productivity that the management concepts under which it is run are sound.

"We could tell a great deal in a very short time" with such a lab is the feeling of one official. However, he does admit that the organization would be under a tremendous obligation to perform and would feel a real need to solve a real military problem. This could produce misleading results, since people tend to perform better if they feel that the importance of their work is being recognized.

Another approach would be to create a lab, or assign an established lab, a unique departmental mission—combining in the one lab the true research functions as well as systems analysis and design. In other words, the lab would be designed to match the assigned mission.

• **Bell report**—Awareness of the declining quality of Defense in-house laboratories was highlighted by the issuance of the Bell Report on Government Contracting for Research and Development in April, 1962. A major conclusion of this report was that "in recent years there has been a serious trend toward eroding the competence of the Government's research and development establishments. . . . We believe it to be highly important to improve this situation . . . by sharply improving the working environment within the Government."

The Bell Report recommended three major actions:

—Ensure government R&D establishments are assigned significant and challenging work.

—Simplify management controls, eliminate unnecessary echelons of review and supervision, and give to laboratory directors more authority to command resources and make administrative decisions.

—Raise salaries. The third point seems to have been taken care of with Federal pay raises but, even with the actions resulting directly from the Bell report, there is much to do in the other two areas.

A separate DOD study levied on DDR&E by Secretary McNamara, Task 97, confirmed the thesis of the Bell report and resulted in an even more thorough analysis of the conditions which have made such labs as the Naval Ordnance Test Station and Naval Research Lab outstanding.

DDR&E Director also asked the Defense Science Board to review the Defense laboratories and make recommendations. All of these studies, plus service studies, call for change. The major question, and the one still unresolved, is how extensive a change is needed.

convenience as an ordinary telephone: that is, easy-to-recognize voices, ability to make conference calls and essentially unrestrained switching. . . . Most important, we would like to see radical improvements in speech-processing techniques to provide better use of narrow bandwidths."

• **C&C**—One of the most difficult aspects of tactical war is command and control. And of all the C&C challenges the most severe is the closer integration of ground and air forces for all missions: close support, interdiction, anti-tank operations and reconnaissance.

"This problem was with us in World War II," a DOD expert notes, "some advances were made in the Korean War, and improvements in equipment and procedure have come about since. . . . Ideally, what is wanted is a system so interchangeable that a variety of weapons, ground and air, can be marshalled against a target with good coordination and control, without the need to have special procedures for any one segment of this system."

One part of this problem discussed earlier is the marriage of aircraft and missiles with a forward observer. A lightweight, portable close-air support radar to exercise this positive control is a critical component.

More difficult of resolution is insuring positive control over ground weapons. With infrared-homing missiles, such as *Redeye*, in the hands of the individual soldier, friendly aircraft become as vulnerable as the enemy's. There is no Identification, Friend or Foe (IFF) for weapons such as *Redeye*.

Hence a valid question has been raised as to whether the air defense missile is a usable weapon. Except under conditions of absolute air superiority (when *Redeye* wouldn't be needed anyway) the Air Force would be loath to have soldiers equipped with weapons which would be a threat to their aircraft.

It is likely that, as in past wars, there would be some sort of "guns tight" policy, under which, even if attacked, the ground forces are enjoined against firing at aircraft.

To make *Redeye* a usable weapon, Defense officials suggest that the only answer is to assign aircraft corridors through which to fly. But they add that this is a major command and control problem which requires resolution.

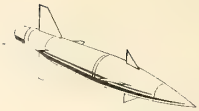
• **Tactics obsolete**—An awareness of the inter-relationships of men, materiel and tactics complicates the development of equipment for limited war. There is a general feeling at Defense level that equipment already in the hands of the troops is not being utilized to its maximum advantage—in fact, there is a conviction that outmoded tactical concepts and inexperienced oper-

500 billion gallons

THIS IS THE VOLUME OF FUEL CECO SYSTEMS HAVE HANDLED—ENOUGH TO SUPPLY FUEL* FOR EVERY PRIVATE AND COMMERCIAL CAR AND TRUCK IN AMERICA FOR THE NEXT 7 YEARS.

Such a record doesn't just "happen." It demonstrates the reality of four words we use frequently—*control is our business.*

Applying this experience to systems for missile flight control is now one of our major assignments. Power source may be hot gas or cold gas, and actuation may be hydraulic or pneumatic.



Most important is that we are "at home" in any one or any combination of these disciplines. The result is that CECO controls and systems perform their tasks with a reliability born of years of experience in the design, development and manufacture of fluid systems and controls.

Superior performance can be depended upon because—*control is our business.*

**on basis of 1964 consumption*

Colt Industries **Chandler Evans Control Systems Division**
WEST HARTFORD, CONNECTICUT 06101

GAS TURBINE FUEL CONTROLS/PUMPS • MISSILE CONTROL SYSTEMS/SERVOS • AIRCRAFT/ENGINE ACCESSORIES

ators preclude accurate evaluation of the capabilities and limitations of materiel.

While citing the lessons of Viet Nam and Laos as proof of the efficacy of simple gun systems, Defense officials also point out that the high losses in the air raids there are also related to pilot training.

Now that World War II and Korean War pilots have left the ranks of combat, aircraft are manned by men who have to learn their job under fire, an expensive and selective school.

Materiel has changed considerably since Korea, and tactical concepts have not kept pace. Aircraft are faster, missiles provide accurate stand-off firepower, and rockets and machine guns are more lethal. However, it is impossible to evaluate one aircraft against another because the conditions under which they would be employed and the ordnance mix they should carry are not empirically known.

In a different context, the same criticisms are leveled against the tactical doctrines covering the employment of armor, anti-tank weapons and close air support. Tanks, facing anti-tank weapons with kill probabilities approaching unity, cannot use familiar tactics. On the other hand, anti-tank weapons which rely on wire guidance to achieve these fantastic kill probabilities must at the same time evolve employment concepts to minimize the long times of flight involved.

Finally, the *Redeye* problem outlined earlier may be amenable to solution by a revision of tactical concepts for close air support.

Summarizing the situation, a Defense official sees two problems: "We are having to re-learn tactics" in places like Viet Nam and Laos and "relevant military experience has not kept pace with the systems" which have been developed.

- **Raison d'être of JTF-2**—This deficiency in tactics is the reason that Joint Task Force 2, which will test low-level penetration and the need and effectiveness of penetration aids, was "forced into being by DDR&E" over the opposition of the Joint Chiefs of Staff.

JTF-2 will collect data in field exercises with various aircraft and ordnance loads. The tests will have a high degree of instrumentation in order to yield a few empirical numbers on the relative effectiveness of various aircraft/ordnance loads.

This non-linear problem is not a competition between weapons but an attempt to evolve the best tactical doctrines for low-level operations based on quantitative data. Also, DOD wants to know the value of penetration aids as an adjunct to low-level delivery of weapons.

In a way, JTF-2 resembles the offense-defense "duel" that has been under way in the strategic field. Here, DOD has taken advantage of the *Nike* anti-missile test program to improve the effectiveness of its offensive weapons. Similarly, aircraft will be flown against various types of air defenses. Thus, the effectiveness of both will be enhanced.

"Right now, when someone comes into this office and says that such and such an airplane can do this and that with this amount of ordnance, I don't know if he's right or not," is the way one official summarizes the situation. "I may know that the airplane stripped and with a test pilot flying it cannot possibly do what is claimed—but I can't prove it. And this is what JTF-2 will give us: some numbers we can hang on these airplanes."

- **Air assault, a question mark**—With the dissolution of the Air Assault Div., DOD must determine what it proved and how it should be applied to the Army. Results of the division's experience are under evaluation by the Joint Chiefs of Staff, and it will be some time before their recommendations are available to Secretary McNamara. Then it must be decided how fast and to what extent these recommendations will be implemented.

Whatever the results, Defense officials feel that the Air Assault Div. showed considerable imagination and ingenuity. They anticipate that some form of air assault unit will be organized. The Army itself may be a stumbling block, since there is some feeling that the expense of large-scale implementation of the concept would deprive the rest of the Army of needed equipment.

- **Immediate future?**—One of the major differences between strategic war and tactical is that the former is much "cleaner" in terms of measuring the cost/effectiveness of weapons. It really amounts to "strategic-economic" war, according to one official.

In the tactical field, however, values are far more difficult to calculate. Tactical war depends more on man-machine relationships; it is less of a science and more of an art.

Because of the very complicated interrelationships between men, materiel

CLEAN LINES of this ship illustrate major Navy problem: provision of adequate fire support for amphibious landings.

INDUSTRY INITIATIVE that may pay off handsomely is illustrated by General Dynamics decision to build Charger aircraft (left) even after DOD decision to award contract to North American design (right). Competition between two planes may well take place before final procurement decision is made. Aircraft will be used by all services.

and tactics, development decisions are much harder to make.

"This is a period of consolidation," says one Defense official. "We are really looking for balance in tactical warfare right now and trying to identify and eliminate those areas in which we are weak."

Most noteworthy of these areas is surveillance of the battlefield. The key to present Defense thinking is just this: "We want to stop and derive the benefits from advances already achieved. Rather than go another round in exploratory or advanced development, we feel it would be better to concentrate on improving the weapons we have today. For example, an accuracy of ½-1 nautical mile in aircraft navigation may be enough, if the pilot has enough time to gain confidence that the system will perform to that accuracy consistently."

Some developments DOD is looking for in the immediate future are:

—Longer mean time between failures in equipment in the operational environment. MTBF testing in the laboratory or in special flight test is giving optimistic results. Also, much avionic equipment does not include the self-check features that are feasible now.

—Better work to match advanced conventional ordnance against its targets. Also, since aircraft use rocket ordnance extensively, the shelf-life of these weapons must be increased. Solid propellants for this and other applications may become unreliable just sitting on the shelf.

—Better power supplies for communication. "We won't be satisfied," a spokesman says, "until we have equipment that has indefinite life, negligible weight and never requires maintenance."

—Better night vision devices. This is one area in which DOD feels that considerable progress has been made. Everyone M/R interviewed felt that it was a truly significant and important new capability. However, DOD would like to see image intensification devices "with one-thousand-yard range on a dark night, wide field of view, negligible weight, no trouble."

• **Big money**—Funding for limited war R&D is the largest category in the development budget. In FY '66 $2.07 billion will be spent as opposed to $1.02 billion for strategic weapons, $1.67 billion for space and $1.52 billion for research and exploratory development. In FY '65, tactical spending was $2.03, while in FY '64 it was $2.13 billion.

Ratio of the development-to-production budget is expected to increase. This is consonant with Secretary McNamara's concept of Deployment to Production combat sufficiency, under which forces would fight with available weapons until the production base could begin turning out a steady flow of these weapons. Thus, many more weapons would be in development at any one time than will ever be produced in large quantities. Enough of certain arms will have to be produced to equip and train combat forces.

This means that large-item procurements, like those of the C-5A and the F-111, will decrease. It also means that the mix of weapons will be larger than ever before and that the U.S. will have a tailored army with tailored supplies. It presents serious planning problems, however, since an incorrect estimate of the amount of production required for training and initial combat could have disastrous results.

• **General vs. special equipment**—Disagreement also exists over how much special-purpose equipment, designed for a specific environment and a particular type of warfare, is needed.

Under the present system, the Army specifies its equipment for all extremes of environment, as do the other services. This means that a rifle must be able to function in the high-humidity, high-temperature environment of the tropics, in the low-humidity, high-temperature of the Sahara and in the cold, dry climate of the Arctic. The question now is whether all equipment should be subjected to these criteria—or would it be cheaper and more effective to design equipment for a special area?

For example, STRICOM has responsibility for Africa, South of the Sahara, as one of its missions. How important is it, then, that its equipment function in the winters of Korea? Or, conversely, the mission of the Seventh Army is the defense of Western Europe. How critical is it that that Army's equipment be able to function in the oppressive environment of the tropics? Further, isn't the equipment required to support a war in Western Europe markedly different than that required to defeat the Viet Cong?

Finally, isn't there a lesson to be learned from India's difficulties in fighting the Chinese in the Himalayan highlands, where every pound is critical? In this rarefied atmosphere, breathing becomes a very real effort and the combat load of a soldier has to be minimized. But the same reasoning obviously does not apply to a war conducted at sea level.

That there will be some attempt to specialize equipment for both area and mission is not disputed; the question is how much specialization should take place. Some officials contend that this would require seven complete sets of Army equipment and would result in the fragmentation of the Army into units equipped to fight in only one area of the world. Also, they say, the expense would be inordinate.

CO-PILOT

Today's Minuteman is more than a super-reliable missile.

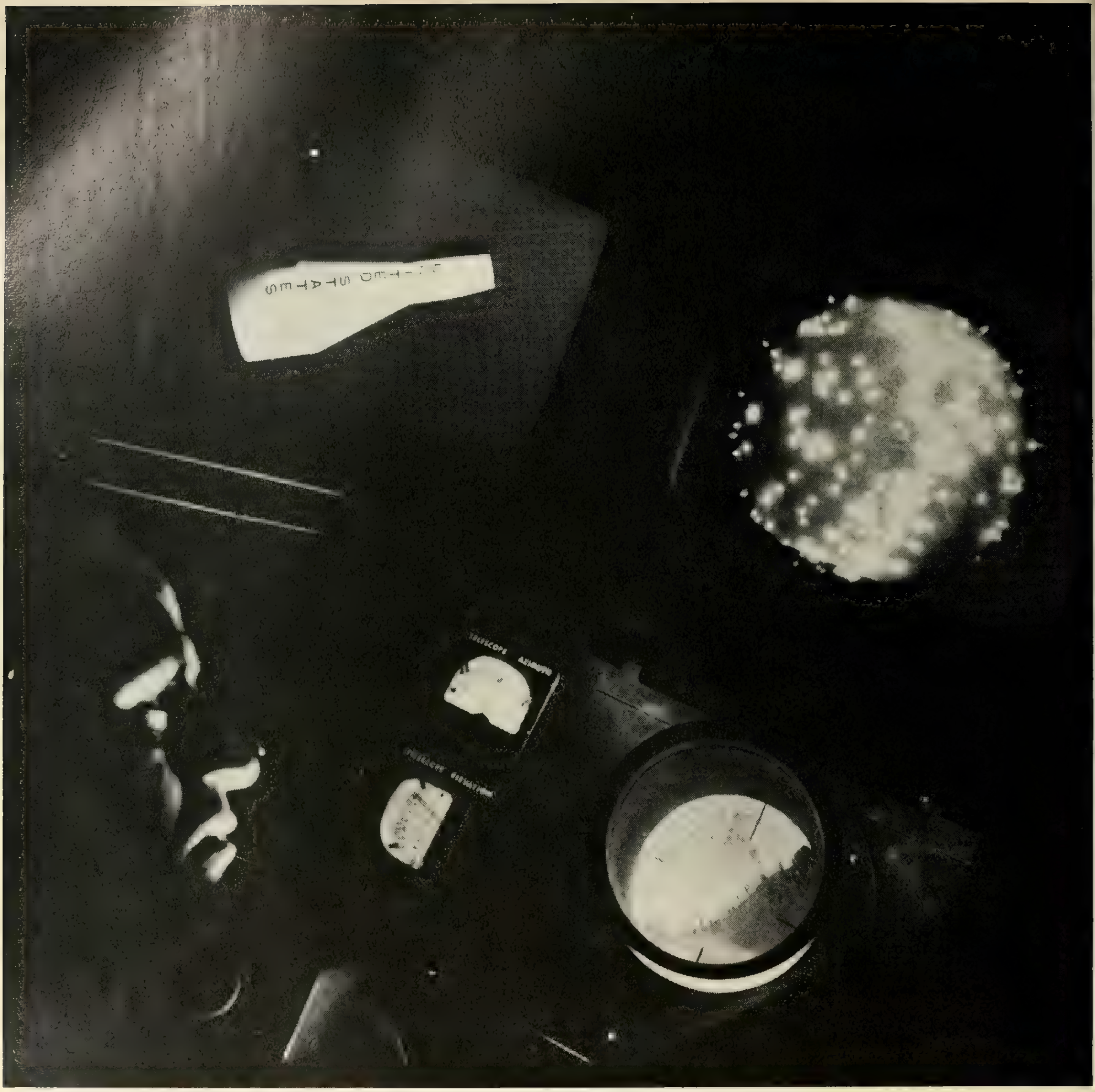
It is a spearhead of electronics progress—technology that is making it a co-pilot by proxy in low-level supersonic aircraft.

It is the forerunner of microelectronic low-level penetration systems by NAA/Autonetics that spot and evade obstacles with unprecedented accuracy. These new NAA/Autonetics systems are based on proven Minuteman techniques and systems management experience.

Autonetics built the fully-integrated microelectronics systems in Minuteman II; was the first to apply microelectronics to production-line systems. Its achievements in this field are setting a whole new standard of reliability in the electronics industry.

For more information about Autonetics total systems capability in meeting the electronics needs of the future, please write: Director of Marketing, NAA/Autonetics Division, 3370 Miraloma Avenue, Anaheim, Calif.

North American Aviation Autonetics Division



Try·on room for space systems:

OLAFS is a unique space simulator developed by Douglas to provide a means of tailoring space control systems to man's abilities.

It uses closed-circuit TV, computers, spacecraft models and other devices to simulate control problems in space. It is being used by Douglas researchers —young men conditioned by confinement in a simulated space cabin to approximate the physical and mental state of astronauts on an actual mission —to practice rendezvous in orbit, lunar and atmospheric landings and surveillance assignments.

Thus, Douglas is acquiring the knowledge required to integrate man with machine components for optimum control. OLAFS is an example of the realistic approach of Douglas to outer space problems, a factor in the outstanding reliability of Douglas space vehicles.

DOUGLAS

MISSILE AND SPACE SYSTEMS DIVISION

Other officials point out, first, that it is unlikely that the U.S. will become involved in conflict in all areas of the world. Therefore, it is unnecessary to develop equipment for all areas, but only for those in which our foreign policy objectives may require military support. Second, they say, not all the equipment of the Army would be specialized—only that which is most sensitive to the environment.

How far this concept of specialized equipment will be carried is still undecided. That it will have an impact on future hardware R&D cannot be doubted.

- **Industry initiative sought**—Industry must realize the contribution it can make to tactical warfare programs. Industry, with its tremendous technological strength, knows far better than DOD or the services what can be done. Therefore, it has a responsibility to suggest and advise on what the state of the art will support. This is strongly stressed by Defense officials.

Imagination and initiative will be rewarded by development contracts. Three excellent examples of industrial initiative which will mean profit dollars to the companies involved are *MAW*, the Charger COIN aircraft and the *Hornet*.

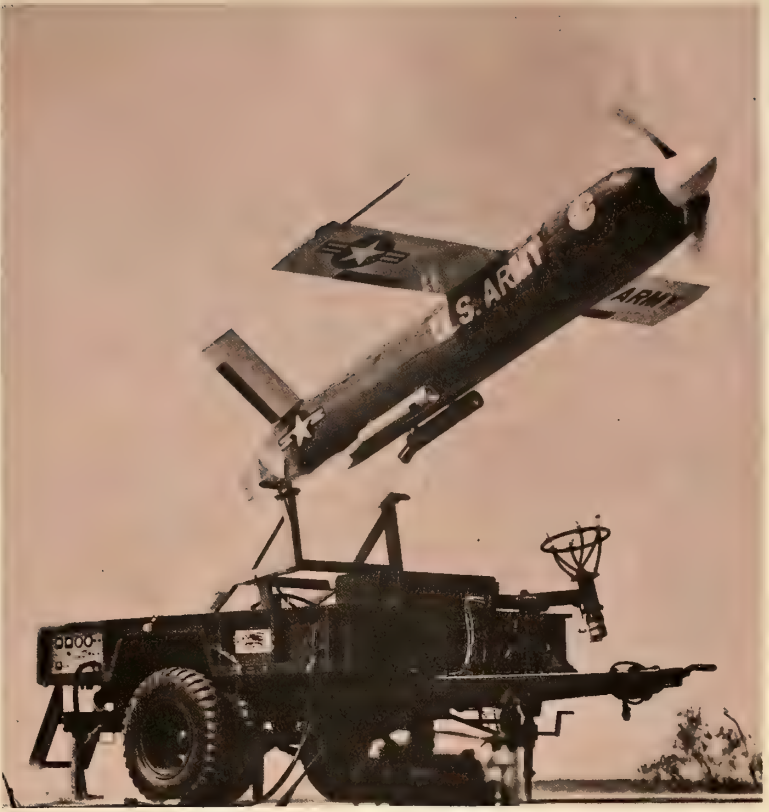
MAW, the *Medium Assault Weapon*, is not yet approved for development, but if it is McDonnell Aircraft Co. probably has the contract locked in, as a result of an unsolicited proposal submitted to, and accepted by, the Army Missile Command. McDonnell is presently working on a feasibility demonstration of the weapon.

Charger was the General Dynamics entry in the COIN/LARA contest, which was won by North American Aviation. The company decided to go ahead and build the Charger anyway, on the basis of potential foreign sales. Now, the Defense Department may well look at both airplanes and decide which one it will buy.

"No one has told us to evaluate the Charger yet," one official says, "but we're all aware that it is flying. And I expect that we will want to look at it before we make a final decision—especially if North American has any trouble."

This could represent a substantial procurement for either company, since the Defense Department plans to buy a substantial number of the planes for use by the Marines—and the Air Force and perhaps the Army—as an interim surveillance aircraft.

Present contract calls for seven aircraft at a total price of $18 million. A flight-test evaluation program is then planned. However, a Defense official told M/R that, "if we did not intend to go beyond the seven airplanes, the PDP for the COIN/LARA would never have been approved."



BATTLEFIELD SURVEILLANCE is one of the critical aspects of tactical war. MQM-58A recoverable drone is now being evaluated to help meet requirement.

A third example of initiative is the unsolicited proposal from the Columbus Div. of North American Aviation which is being funded by the Air Force Tactical Air Warfare Center. This is the *Hornet* air-launched anti-tank rocket. Defense officials are enthusiastic about the weapon and expect a development decision in the near future. Feasibility demonstration firings have been held at Eglin AFB, Fla.

- **Close-support aircraft**—A future decision by the Air Force and Defense officials could spell substantial business for industry. The Air Force this year will conduct studies of a new close-support aircraft configured especially for ground attack missions.

Its size would be less than that of the F-111 and its range would also be circumscribed, but its low unit cost would allow procurement in large numbers. It would be a replacement for the A-1E. Present planning would put the aircraft in the inventory in the early 1970's.

Meanwhile, as an interim measure, the Air Force is evaluating versions of such aircraft as the A-6, the A-7, F-5 (another example of company initiative) and the fighter-bomber F-4 for this mission.

After this paper evaluation the Tactical Air Command will conduct tests on the most promising candidates. These tests would encompass field exercises with ground troops. A decision is expected during FY '66, and $10 million has been included in the FY '66 budget to begin modification of one of the attack aircraft. ■

Additional Copies Of Missiles and Rockets' Annual DOD Issue

Extra copies of this issue, featuring the Special Report beginning with this article, may be purchased from:

Research Department
Missiles and Rockets
1001 Vermont Avenue, NW
Washington, D.C. 20005

Price per copy is $1.00. Bulk prices upon request. Payment must accompany order.

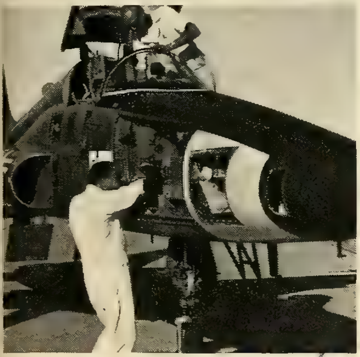
An airplane that is designed to protect and support ground forces is called a tactical fighter.

A tactical fighter must prevent hostile aircraft from attacking tactical targets. It must be able to intercept, outmaneuver and shoot down any intruder which penetrates at low enough altitude to be a threat (anywhere from the treetops to 30,000 feet). To do this it must have supersonic speed, rapid acceleration, a very high rate of climb and outstanding maneuverability. It must have greater endurance than its antagonists. It must carry cannon as well as air-to-air missiles.

A tactical fighter must be able to attack and destroy military targets on the ground while surviving in the air. It must carry a variety of external weapons—missiles, bombs, rockets, napalm, dispensers—and must provide a stable launching platform for them. It must maneuver easily and safely at low altitudes with a heavy load of stores. If attacked by defending aircraft it must be able to counterattack.

A tactical fighter should be able to operate from dispersed fields and hastily prepared strips close to the combat zone – rough sod, packed earth, pierced-metal planking. It must be simple to rearm and refuel so it can turn around quickly between missions.

A tactical fighter should have a very high sortie rate—which means that it must be rugged, reliable and easy to maintain. All systems and components should be quickly accessible from ground level. Engine changes and field maintenance should not require heavy equipment. Maintenance man-hours should be very low.



A tactical fighter should be designed to survive combat damage and operational emergencies. It should present a small target to radar and ground fire. It should have redundancy where it counts—twin engines, dual hydraulic, electrical and fuel systems. It should be able to complete a mission and return to base if one engine is shot out, then take off on its remaining engine and fly to the rear for a replacement.

A tactical fighter should be readily adaptable to all types of support missions, including reconnaissance. Versatility and long-term growth should be designed into it from the start, so that major surgery will not be required to give it new weapons and avionics.

U.S. AIR FORCE
05
RESCUE

The Northrop F-5 is a tactical fighter. It was designed to fill the total tactical requirement and still be affordable in large numbers. The F-5 is now in full production for deployment to nations throughout the free world.

NORTHROP F-5

ASBESTOS PHENOLICS

R/M VALUE ENGINEERING GUIDE

[illegible] Division, Reinforced Plastics Department, Raybestos-Manhattan, Inc., Manheim, Pa. 17545.

Asbestos Phenolic Multi-Ply Tape Speeds Parts Wrapping Time by 75%

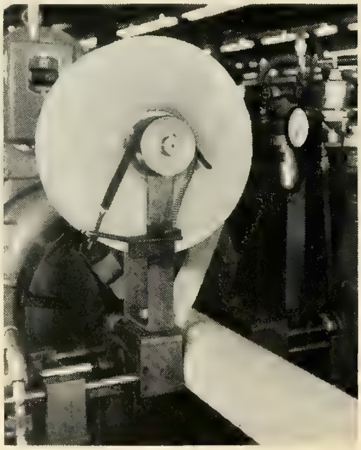
R/M Style 41-RPD Multi-Ply Tape

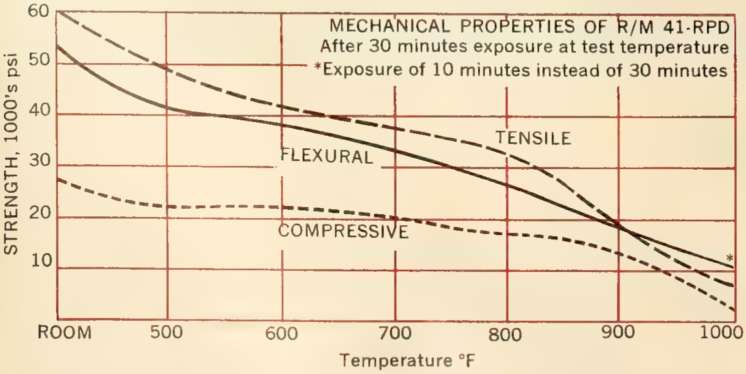
In your value analyses of high-temperature parts for current or advanced aerospace hardware, you should consider the cost saving reliability of R/M asbestos phenolics in general—and this pre-preg *multi-ply* "B"-stage laminating tape in particular.

Designated R/M Style 41-RPD, this remarkable material is available in from 1 to 4 plies and with different percentages of heat-resistant phenolic resin to meet specific flow requirements. Lightweight and low in cost, it offers reproducibility with reliability for ablation-resistant structures such as rocket motor liners, exit cones and missile skin. Its superior performance characteristics have been demonstrated in numerous missile firings.

75% faster wrapping time

High-temperature parts can be wrapped with Style 41-RPD up to *four times faster than with any single-ply tape*. Higher tensile strength of 41-RPD Multi-ply permits tighter wrapping tensions for more uniform results, improved appearance and better performance. (For mechanical characteristics, see graph below.) Multi-ply constructions of R/M Style 41-RPD can be specified in tape widths of 1 to 4 in. Single plies in all widths are of a nominal 0.010-in. gauge.


Tape wrapping with Style 41-RPD tape.



Circle No. 37 on Subscriber Service Card

Asbestos Phenolic Molding Compounds Trim Missile Costs and Weight

R/M asbestos phenolic molding compounds are a good starting point for low-cost, lightweight missile parts that must withstand direct contact with burning propellents or other extreme-temperature environments.

Nose cone molded of R/M Style 190-RPD compound

R/M Style 190-RPD, an economical dry molding compound of the asbestos-phenolic type, has proved its utility in parts subjected to temperatures ranging from −160°F to over 10,000°F. Utilizing a high heat-resistant phenolic resin and medium-length asbestos fibers, it exhibits a smooth and uniform rate of ablation. Other desirable characteristics include good structural strength, excellent dimensional stability, excellent thermal insulation and low thermal diffusivity.

Recommended applications include nose cones, rocket motor insulators and structural and leading edge configurations. Consult your company's VSMF microfilm catalog, or write for technical and product data.

part II

technology

Materials Development Is Crucial To All Areas of Military Weaponry

AN INITIAL SERIES of analytical studies designed to pinpoint the technical developments responsible for the existence of successful weapons systems programs indicate a surprisingly large contribution by those technologies grouped under the broad classification of materials.

The present results are somewhat less than statistically meaningful—but if the trend continues through similar studies into large weapons systems, materials technology may prove to be the dominant factor.

The first attempts at describing the key advances leading to operational weapons involved the *Bullpup* system. The next series will cover far more sophisticated systems where both the temperature and performance levels are orders of magnitude higher.

Materials technology is ill-defined within the DOD structure and attempts to correlate materials efforts with annual expenditures have been extremely difficult. The personnel concerned with managing, developing and researching the broad area of materials agree that the technology cannot be broken into strategic and tactical categories.

Materials themselves and their design applications tend to permeate the McNamara management scheme without regard to artificial categories such as exploratory, advanced and engineering development.

Quite often it is a materials problem that contributes to the cancellation or stretchout of any concept—either directly or through the cost factor.

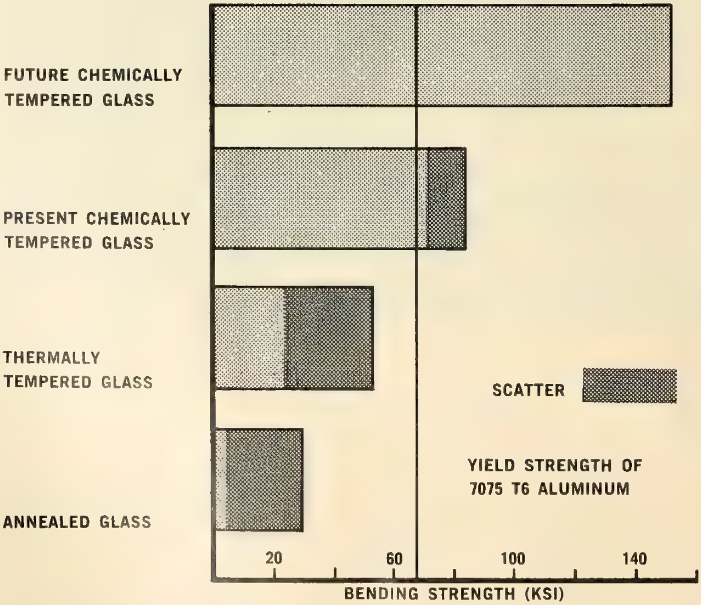
Materials technology is no respecter of other technology classifications. There are materials problems in electronics, guidance, propulsion, explosives, aircraft, tanks, ships and submarines.

Thus to point to any given materials area as directed toward limited warfare as against strategic needs can be fundamentally misleading. Even the mundane field of armor may borrow heavily from ceramics and composite materials work in re-entry and other high temperature structural techniques.

The answer to a problem in ground vehicles designed for rough terrain may be back at the raw metal ingot and the metal-working processes applied to it.

- **Wide world of materials**—The Army, Navy and Air Force have materials programs spread across the entire spectrum of U.S. technology. There is a considerable amount of coordination and cooperation—primarily designed to avoid unnecessary duplication. But a certain amount of duplication is necessary simply because of the unique materials needs of the three different services.

There is no materials czar in the DOD structure, although at least two of the services have been able to coordinate



THE STRENGTH and reliability of monolithic glass allows its use in applications heretofore excluded. The increased strength of chemically tempered glass opens extensive applications in modern military aircraft. But the same improvements in the material that prompts more critical use and design also emphasize the importance of determining exactly what the respective contributions are, to what limits they can be carried, how efficient a design can be and how the test results can be utilized. (Chart courtesy of N. E. Promisel, ASTM Gillette Lecture.)

effectively all of their materials efforts.

There is a substantial, fundamental approach directed at DOD levels and primarily through the Advanced Research Projects Agency, which is laying the groundwork for an entirely different "revolt" in the materials "revolution." This ranges from interdisciplinary research designed to provide both basic scientific work and the highly trained people at the doctorate level to a planned attempt to tie basic and applied work together in various generic military materials problem areas.

At the other extreme, the massive attack on all forms of corrosion is generating a unique program designed to move in the opposite direction. This particular project is just starting and is designated as Controlled Materials Degradation. The idea is to take advantage of weaknesses in materials and use this knowledge against an enemy in the field —a sort of materials warfare.

The short history of the so-called materials revolution—which began in the early 1950's with the emergence of the missile—has seen the applications reach almost to the limit of the materials' ability to perform reliably and satisfactorily.

This impetus has in turn created newer, more complex and temperamental materials reaching ever higher in strengths, temperatures and environmental abilities.

- **Analysis challenge**—The hidden problem is in the tests applied to these materials and the designs resulting from such data. The nature of the materials themselves have far outstripped the ability of time-tested analysis to derive meaningful design data.

Although much progress is being made, most of it with the insistence and funding of the military and NASA, the testing problem is still severe. It extends into the intelligent evaluation of the processes used to form and shape materials into weapons.

Throughout the military, the constant and urgent request is for lighter equipment—yet more reliable and rugged. The demands seem almost idealistic, but the materials are available and have proven themselves in many applications.

The real problems are in confidence levels, design information and the ability to use and understand highly sophisticated test data. The secondary problem is in developing the data through new, yet reliable, test procedures.

- **Product gap**—The essential weakness covering the entire spectrum of materials is the lack of processing and design ability. There is a crucial gap between the lab and the finished product—be it tactical, strategic or support equipment—which is not being filled.

There are programs being imple-

Miles and Miles of Boron

THE MOST POPULAR subject in the materials field today is the boron filament. Yet the real reason for the emphasis on this material is that it may serve to bring the whole area of composites out of the specialty corner and into major use.

The potential of boron filaments in structural applications is exciting officialdom—clear up to the Chief Executive. But the catch is not in the material itself but in getting it into usable shapes.

Fabrication and design in composites is the real problem. Unless there is a complete cooperation among materials researchers, fabricators and designers, the on-paper potential of boron, glass, carbide, graphite and all other fiberous and filamental materials will not be realized.

The boron work in the U.S. is largely supported by the Advanced Filaments Division of the Air Force Materials Lab at Wright Patterson AFB, Ohio. Under the direction of George Peterson, this group is directly attacking the materials/fabrication/design barrier. Boron is the current focus of this drive.

"In and of itself," says Peterson, "boron is just another material. Its major contribution is in opening the door to higher moduli in composites. All the filament development in the world is useless without reduction to useful, composite products."

The demonstration of a useful product form from filaments such as boron is the most expensive area —not the development of the material itself.

- **No middle step**—There are no intermediate shapes in composites. The historical use of homogenous materials has always depended on mill products such as rod, bar, sheet, boards and other formable shapes. A composite starts with filaments or fibers on one hand and a matrix material on the other—and goes directly to the final configuration.

Thus designer does not work with handy materials specification tables in developing composite shapes. The structural stresses and strains inherent in the final shape must be met by the component materials in various combinations through radical fabrication techniques.

Boron has moved fastest in relation to other filament materials—but it is only now reaching the production amounts necessary for structural shape development. The production approaches to boron filaments are classified but are generally through some form of vapor deposition.

The boron filament itself is not a true filament. It behaves like one, but it actually has a core of a different material. The ideal production process would be drawing from the pure melt—as in glass filament manufacture—but the complexity of this has proven sufficient to force other adequate, but less desirable, solutions to the problem.

Boron filaments approach the best glasses in strength—but its major characteristic of interest is its modulus, or stiffness. Tests show that boron can support more than five times the load supported by low-carbon structural steel.

- **Industrial interest**—Boron filaments, their production and application are being actively researched by extremely competent industrial firms. Texaco Research, Astro Research, Narmco, Avco/RAD, General Electric, at both Valley Forge and Schenectady, and the United Aircraft Research Labs are the front runners in the field. None of these industrial firms limit their work to just boron. It is one of the many filament and fiber types under study.

There is another aspect to composites, and this is the matrix material—most often plastics but sometimes metals. The relationship between the reinforcement and the matrix is not understood. The Advanced Filament Div. is funding efforts by industry and military labs in this area.

There is a definite sense of realism exhibited by most people concerned with the development of composites. They are well aware that composites are not a panacea and that there exist many applications where homogenous materials enjoy absolute supremacy. Most of the leading experts in the composites fields are well-versed in engineering with homogenous materials.

But many applications exist where the composite approach will provide solutions far exceeding the ability of conventional materials design.

mented, but the funding is necessarily inadequate. These are the areas first to feel budget cuts when emphasis must be placed on other military programs. Yet these are the same areas that are flooded with money when crucial programs reach beyond the current state of the art.

In general, the state of the art in processing and fabricating materials is still about 80 years old. New concepts and techniques are fought bitterly by both industry and the military for good reason. These cost money all out of proportion to the immediate market, and commercial applications are slow to develop.

In the broad field of metal working there is a joint effort sponsored by all the services and NASA designed to focus metals deformation knowledge on metal deformation processes. This program is designated the Metalworking Processes and Equipment Program (MPEP). It is now in its third year.

The reason for its existence is relatively simple. The higher strengths and lower ductilities characteristic of recent high-performance metals imply greater difficulty in fabrication.

Besides the difficulty in forming and joining, the processing problems in forging, rolling, extruding and other similar production methods often result in cost penalties and quality difficulties.

N. E. Promisel, Asst. Chief, RDT&E, Materials, Navy Bureau of Weapons, says these difficulties may stem as much from the inadequate application of scientific understanding and phenomena to metal working techniques as from the natural reluctance of these deliberately created materials to deform when subjected to procedures designed for other kinds of materials.

• **New forming techniques needed**—Too often, he says, a mild steel rolling technique has been used to evaluate rollability of a high-strength material, with resulting condemnation and rejection of the latter for not responding properly.

Promisel's point is that the need is great for new and radical fabrication techniques based on an understanding of the materials being formed. In this he is in complete agreement with materials experts in the other services and within the DOD management.

The usual approach is to take a material designed to resist deformation in extreme environments and fabricate it by first weakening the material itself. The intelligent approach would be to adjust the forming process, not the specially created material.

For example, there is a resurgence of interest in powder metallurgy—an effort to use powder processing to convert raw stock to parts without going through a melt phase. There are things possible here not possible through conventional melting approaches. This area alone will provide radically different processing techniques both in the raw stock to mill products segment and in forming to end items.

• **New ideas in processing**—There is substantial work going on in the processing areas. The main task is to convert the lab methods to practical, efficient and economical production techniques.

One example is a phenomenon involving deformation at varying pressures. A series of tensile tests on a sintered tungsten bar at room temperature under different pressures illustrates this point. At ambient pressures, the tungsten specimen failed in brittle fracture—as expected below the transition temperature of the metal.

But as the pressure was increased, the fracture mode became ductile at the same temperature. Under a pressure of 350,000 psi., the sample was pulled to the limit of the testing device without failure but with obvious ductility. High pressure could be the route to tungsten forming.

Another example is the incorporation of energy modes into the forming technique. Applying ultrasonics to the die in certain extrusions of hard-to-form metals resulted in fooling the material and a remarkable ease of deformation.

There is a growing amount of experimental evidence indicating that the use of such energy forms may well be capitalizing on some unknown characteristic of the materials themselves. One group of such experiments involving the application of ultrasonics to single crystals of aluminum resulted in a dramatic drop in the stress-strain curves. This indicates an innate response to the energy by the material.

The emphasis on processing technology being pushed by the military is not directed at incremental improvements. The search is for the logical process, not the classical one.

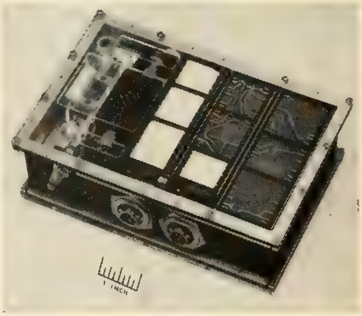
The same trend is visible in all materials areas, not just metals. The compressive strengths and high temperature properties of ceramics are needed badly. But how do you make good sized chunks of reproducible ceramics?

• **Facing the problem**—The inherent problem remains in designing with brittle materials, and the tendency is to design around the material. This does not solve the real problem nor does it exploit the known potential.

There is no real reason why ceramics

EIMAC Aerospace Telemetry Transmitters Excel in S Band Operation

This 2-watt transmitter uses a triode-cavity power oscillator to achieve higher overall efficiency than is possible with all-solid-state transmitters. Frequency stability is achieved by an AFC servo loop referenced to a crystal oscillator. Tuning range is 2.2-2.3 Gc. Total volume is 50 cubic inches. Modulation linearity (maximum deviation from best straight line) is ±0.5% from ±10 Kc to ±300 Kc, and ±2.5% from ±10 Kc to ±1.5 Mc. Amplitude modulation is less than 5%. Susceptibility requirements of MIL-I-26600 are met. The solid state power supply operates from 28±4 Vdc with over 80% efficiency.



For complete information on this transmitter, contact Eitel-McCullough, Inc., San Carlos, Calif. In Europe contact Eitel-McCullough, S. A., 15 rue du Jeu-de-l'Arc, Geneva, Switz.

NOW ALSO AVAILABLE FROM EIMAC
MODEL EM4534 3 WATTS 1.435 TO 1.535 Gc
MODEL EM4567 8 WATTS 2.2 TO 2.3 Gc

Circle No. 52 on Subscriber Service Card

cannot achieve the same level of utilization as glass. Glass alone is becoming more and more attractive because of its compressive strengths—especially in high-exterior-pressure applications such as in deep submergence.

Military interest in composites is semi-infinite, says Promisel, and not limited to structural applications. This is one answer to the many inadequacies of homogenous materials in certain specific applications (see box on boron).

The testing problem is particularly significant in the composites area. The common test now is destructive—filament-wound motor cases are statistically proof-tested by bursting. A considerable savings in time and money could be realized if a reliable, efficient non-destructive test could be used.

There are techniques being developed, but none have yet been adopted in place of the hydro-burst procedure. Non-destructive tests, satisfactorily employed, would contribute significantly to both the processing and design areas in composites.

- **Crucial delay in tests**—The money, time and effort spent by the military in determining the operational status of equipment in the field dramatically points to the need for simple, non-destructive test procedures.

This is a whole new area and covers testing in its broadest sense. The growing effort here is directed to those weapons facing cyclic use—not the one-shot combat use characteristic of a missile.

Aircraft and other high-performance vehicles must undergo periodic maintenance just to determine their combat status. For instance, the complete stripping of paint in the field to examine for cracks and other fatigue failures may not reveal any such indications—but the whole process of stripping and re-furbishing must be performed.

Just developing a simple, portable test method for determining the existence and degree of corrosion under protective coatings would have an enormous reduction effect on the expense of maintaining combat readiness.

Such tests necessarily must be non-destructive since destruction of the equipment cannot be tolerated. Even certain dynamic tests cannot be done since the test itself may introduce weaknesses.

The attractiveness of such testing ability in the field or aboard ship is obvious. Less appreciated is the effect of delay between new materials and processes and the tests used to define their characteristics.

The lack of more sophisticated tests and accurate interpretation of results contributes heavily to fabrication and

New Aerospace Books For Your Reference Bookshelf

All available on 10-Day examination

• READY IN MARCH •

SPACE MATERIALS HANDBOOK
EDITED BY CLAUS G. GOETZEL, JOHN B. RITTENHOUSE AND JOHN B. SINGLETARY
LOCKHEED MISSILES AND SPACE COMPANY
A Group Division of Lockheed Aircraft Corporation

This outstanding reference work provides a collection and interpretation of the effects of space environments on materials as an aid to the efforts of scientists and engineers engaged in designing and constructing spacecraft. The Space Materials Handbook was first prepared as an Air Force sponsored report in 1961 by a team of twenty-five Lockheed Missiles and Space Company scientists in an attempt to collect and analyze the wealth of materials data which had been accumulated in support of several Air Force satellite programs. It was soon recognized that environmental effects data from other sources should also be incorporated to make the volume of most usefulness. The presentation is divided into four broad parts: the space environment, effect of the environment on materials, materials in space (materials applications), and biological interaction of materials. *c 650 pp, (1965) $15.00*

• IN PRESS •

AERODYNAMICS OF WINGS AND BODIES
BY HOLT ASHLEY AND MARTEN T. LANDAHL, *Massachusetts Institute of Technology*

This is a thoroughly modern text covering the classical aerodynamic theory of wings and bodies over a wide range of flight speeds. Two unique features are using the method of matched asymptotic expansions for introducing the boundary-value problems of external flow over thin wings and bodies, and the prominence given to numerical techniques for loading predictions with the use of high-speed computers.
c 320 pp, 128 illus (1965) About $12.75

• PUBLISHED JANUARY 1965 •

COMBUSTION THEORY
BY FORMAN A. WILLIAMS, *Institute for Defense Analyses*

Intended to serve either as an advanced graduate text or as a reference for workers in the field of combustion, this book contains a systematic development of the theory of chemical reactions in fluid flow. An attempt has been made to cover the entire field and the emphasis is on the theoretical aspects of the subject.
447 pp, 75 illus (1965) $15.00

• ALSO •

FLIGHT MECHANICS, Volume I: THEORY OF FLIGHT PATHS
BY ANGELO MIELE, *Boeing Scientific Research Laboratories*

The first volume of a work intended as a comprehensive survey of the theory of flight paths of aircraft, missiles, satellites, and spaceships. This initial volume deals with foundations plus flight in a uniform gravitational field. It is designed for use as a text by advanced engineering students or as a reference work.
416 pp, 219 illus (1962) $11.50

Please send for my inspection and approval, a copy of each book I have checked. (I understand that I can return the books in ten days if I decide not to keep them.)

ADDISON-WESLEY PUBLISHING COMPANY, INC.
Dept. A-456A
Reading, Massachusetts

☐ Goetzel, et al, SPACE MATERIALS HANDBOOK $15.00
☐ Ashley-Landahl, AERODYNAMICS OF WINGS AND BODIES About $12.75
☐ Williams, COMBUSTION THEORY $15.00
☐ Miele, FLIGHT MECHANICS $11.50

Name.................................Title.................................
Affiliation.................................
Address.................................
State.................City.................Zip Code.................

☐ Please extend College Professor's Discount
☐ Payment Enclosed. (We pay postage if you enclose check—same inspection privilege)

Circle No. 53 on Subscriber Service Card

design problems. New innovations in processing described above and the highly probable inventions of even more radical methods in the near future render many of the more conventional data-gathering methods useless for design purposes.

One example cited by Promisel in this area concerns an experimental cable for arresting aircraft on a carrier. The cable was made from wire some 20% stronger than conventional wire, but having 15% less ductility as measured by torsional, twist and wrapping tests.

The "stronger," conventional cable failed at a load 5% less than that of the "weaker" cable. Promisel terms the selection of criteria for assessing strength and true design values in this case as less than useless.

As Promisel puts it. "Today, we are at that exciting stage where we not only design the structure, but, hopefully, are almost ready to design the material itself, describe it accurately in a specification and custom-make it for the particular application.

The degree to which we succeed depends vitally on how sophisticated and understanding we are in our testing, and the effort we can bring to bear on this near-Herculean task." ■

Non-Destructive Warfare

ONE OF THE MORE vital areas of technology within DOD is concerned with the development and use of chemical and biological agents.

The level of development is classified, but the Fiscal 1966 funding is about $125 million. This form of warfare is not easily categorized as limited or strategic, offensive or defensive, because essentially the same agents can be used in any type of action.

It can be broken into two general classes—lethal agents and all others. The latter group comprises a sort of non-destructive warfare wherein personnel are temporarily incapacitated while buildings, structures and landscape are left unharmed. There is even a small amount of effort devoted to agents for other than anti-personnel use.

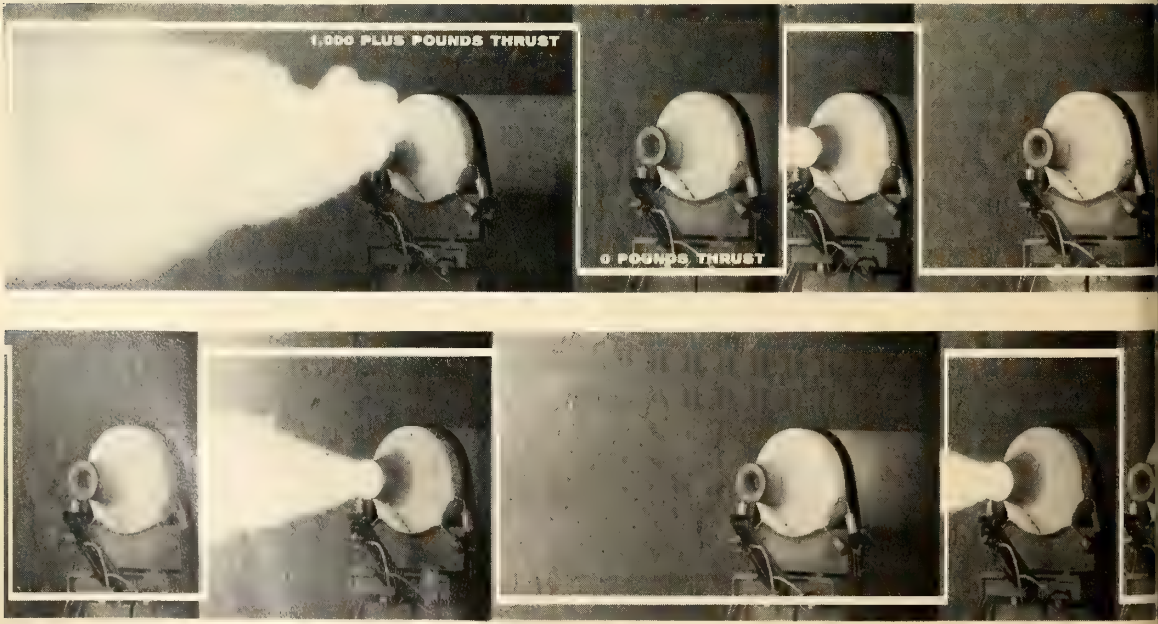
Security classification is imposed for two general reasons. The first is strictly military and obvious. The second is that the area bears a certain "psycho-political" stigma.

But these agents can make a contribution to limited warfare. In addition, the potential enemies of the U.S. are known to be working in this area and their applications may not be restricted to the incapacitating agents.

- **Agents themselves**—Considered as a weapon system, the detailed knowledge which must be acquired before any chemical or biological agent is put to use in the field is enormous—much more than with conventional or even nuclear weaponry.

There cannot be any unpredictable results from using such agents. For instance, it is perfectly possible for a less-than-thoroughly researched agent to produce a totally unwanted effect on the enemy. It could even make him more aggressive.

Now...fire and re-fire...on command



On the other hand, the area of use may contain both military and civilian personnel—and the civilians may well be "friendly" enemies. The problem here is obvious since it would be impossible to discriminate between these two groups with respect to exposure.

The third major consideration is that the use of these agents must not hamper mobility of our own forces.

The complex screening, synthesizing and characterization work in this area has been in progress for about 15 years—ever since the realization that total, global warfare was not the only way to go.

There is excellent support and liaison between the military and industry in the chemical/biological agent field. Obviously few of these agents are all "bad" and any research into their nature benefits both sides.

Most of the agents are large, complex compounds and the difficulty is increased by orders of magnitude in correlating their chemical structure with their physiological effects.

There are also the usual problems with economics, cost, handling, shipping, storage and shelf-life, and delivery systems.

- **Backside of the coin**—The really difficult area in chemical and biological warfare is in the detection and neutralization fields. Here there is a marked difference between the two classes of agents—chemical agents tend to act swiftly with little or no symptomatic warning time. The biologicals, on the other hand, may have early warning symptoms associated with their use, which could permit corrective action.

In both areas, however, the detection problem is complex. Just how complex is easily seen from the laboratory equipment commonly used in analytical work. For field situations, it is impractical to carry mass spectrographs around. A good percentage of these agents are colorless, odorless and otherwise not detectable by the senses—until it is too late.

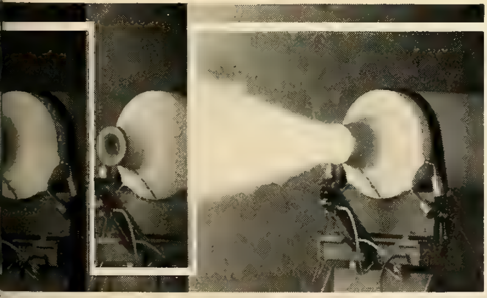
The solution lies in identifying presumptive techniques in the lab and then engineer these for field usage. The route in detection is through identification of chemical and biological classes through some immediate means. This broad identification gives the field commander only the bare facts.

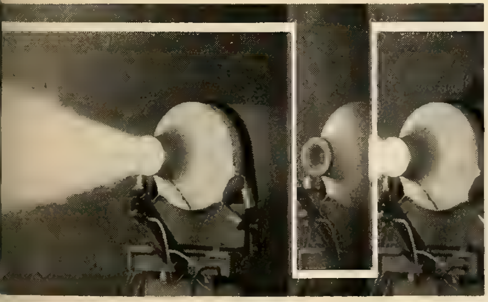
Realistically, all the combatant can know immediately is that such agents are being used in his area and then he must apply general protective measures—a mask, for example. A separate and highly trained group of technicians can then go to work to more clearly identify the threat and propose both individual and mass protective measures.

Detection and identification are separate technical problems. The military problem is worse—even the most highly developed gas mask has some effect on the combat readiness of the individual.

In spite of all the difficulties, DOD experts say the problems are far from insurmountable, and selected use of such agents could provide clear advantages in guerrilla warfare.

rom Lockheed Propulsion: This 40 pulse
lid rocket motor. Fires propellant wafers
conds apart...or days apart.





PROBLEM: Develop a lightweight solid rocket motor which can be fired, shut down, then re-fired, in sequences of seconds, hours or days. This was the assignment of the Air Force Systems Command to Lockheed Propulsion Company.

LPC's solution is a pulse motor which uses solid propellant wafers. Each wafer develops over 1,000 pounds thrust, is separated by a thermal barrier. On manual, radio, or pre-programmed command, the wafers can be fired singly or in rapid bursts. Time between wafer firings can be as little as milliseconds—as much as days.

This latest LPC advance in solid motor thrust control, following company developments in other forms of energy and thrust vector control, opens the door for utilization of solid motors for a wide variety of air-launched or space-launched missions.

In other important projects, LPC has twice test-fired a massive 156-inch solid rocket motor which developed over 1,000,000 pounds of thrust, and simultaneously demonstrated new advances in thrust vector control for the Air Force. Now, a revolutionary emergency ballast expulsion system is being developed by LPC for the Navy. This system uses solid propellant gas generators to pressure-expel tons of sea water from the ballast tanks of nuclear submarines, at least ten times faster than present methods.

PROPULSION ENGINEERS: These wide-ranging, expanding programs offer excellent career opportunities to qualified engineers, extending from junior into management level positions in the fields of preliminary design, advanced design, and analytical engineering. We invite you to write: Professional Employment Manager, Department 5203, P.O. Box 111, Redlands, California. An equal opportunity employer.

LOCKHEED PROPULSION COMPANY

REDLANDS, CALIFORNIA • A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

STRUCTURAL COMPONENTS. Lockheed now employs beryllium in sections of the skin of the Agena D—the first large-scale use of beryllium sheet. It has replaced magnesium panels because of significant weight savings made possible by beryllium's high elastic modulus. BERYLCO has cooperated closely with Lockheed in developing large sheet panels which can be formed and fabricated to aerospace structural configurations and quality requirements.

BERYLCO REPORTS...

Now the bright promise

Over the years, few metals have attracted more interest than beryllium—its unique properties explain why. Experience gained through time spent in continuous development now has turned what was once a laboratory curiosity into a practical design material. Today, beryllium invites serious consideration for use in virtually every aerospace project.

BERYLCO has contributed to this progress in two major ways. One, by applying its resources to advance techniques in beryllium processing and fabrication. Two, by offering a broad range of commercially available mill products. We invite you to discuss the ways in which we can apply these capabilities to your present programs.

For example, BERYLCO has contributed to the application of beryllium in a wide spectrum of aerospace programs, in such areas as instrumentation, optical apparatus, nuclear reactors, structures, space radiators, pressure vessels and jet aircraft brake and engine components. These uses perhaps suggest many others, particularly where beryllium's unique properties can be effectively applied. Due to beryllium's high stiffness-to-weight ratio, it is receiving increased attention for use as a structural material. This lightweight metal compares in density to magnesium, yet its modulus is six to seven times greater.

While aluminum and magnesium alloys melt at slightly over 1200°F, beryllium still maintains its *structural integrity* beyond these temperatures.

Availability of a wide range of shapes and forms enables beryllium to be at the core of new design concepts, rather than a substitute for another material. BERYLCO offers commercial quantities of beryllium in the form of hot pressed and machined products, extruded forms such as rod, bar, tubing and other structural configurations, wire, forgings, sheet in gages .010 to .250 inches, in sizes up to 36″ by 96″.

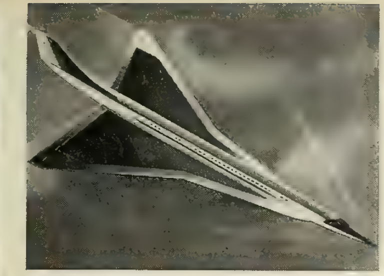
Shown here are some of the many ways in which beryllium is solving critical aerospace design problems. For technical literature on beryllium, or for direct technical assistance, write to The Beryllium Corporation, Dept. X-3, Box 1462, Reading, Pennsylvania 19603.

BERYLCO®

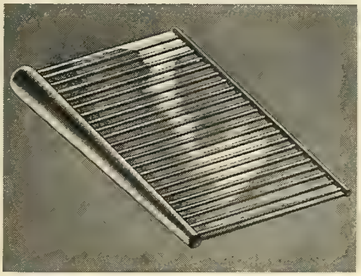
Developers and producers of extraordinary materials

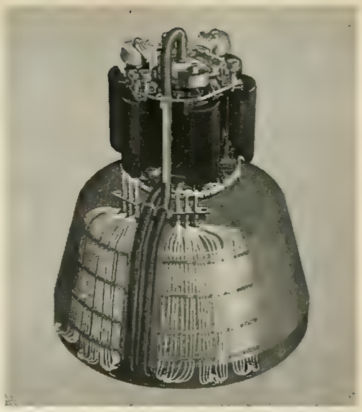
Beryllium • Beryllium Copper • Beryllium Nickel
Beryllium Aluminum • Beryllium Oxide

Circle No. 38 on Subscriber Service Card



BRAKE SYSTEMS. Beryllium brake applications are being developed for mach aircraft, stemming from the need for lighter weight and optimum heat dissipation. From room temperature to 2000°F, beryllium's heat capacity is some 4 to 5 times greater than steel. Possibilities: a heat-sink package with equal given size and heat absorbing potential . . . at a fraction of steel's weight; alternatively, a brake system with radically higher heat absorption, with no increase in total weight over steel.

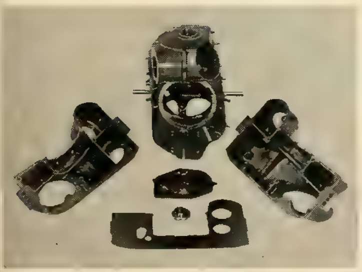




SPACE REACTORS. SNAP 8 is a 35-kilowatt electrical power supply for use on spacecraft. It employs a nuclear reactor heat source to drive a mercury Rankine cycle turboalternator. The reactor is being developed for the A.E.C. by Atomics International, a division of North American Aviation, Inc. Surrounding the reactor core vessel is a beryllium neutron reflector and six Be reflector control drums which maintain proper coolant outlet temperature by controlling reactor power. Beryllium's low thermal neutron capture cross section and high scatter cross section, coupled with resistance to moderately high temperatures, makes it ideally suited for this application.

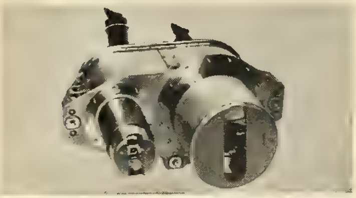
SPACE RADIATORS. Operation of turboelectric solar and nuclear space power systems requires heat rejection through large radiating surfaces. Designs are being developed for beryllium radiators because of its high thermal conductivity/density ratio. Beryllium in radiating fins and tube armor results in lowest specific weight (lb./kw) in operating temperature ranges of both Rankine and Brayton cycle systems.

# of BERYLLIUM is being fulfilled



GUIDANCE AND CONTROLS. Beryllium has emerged in the past few years as the most acceptable material used in precision guidance and navigation systems. Its high ratio of stiffness to density, inertness, and thermal coefficient of expansion are responsible. For inertial instrument use, beryllium must meet unusually stringent specifications requiring metallurgical stability, homogeneity and lack of porosity, because beryllium parts usually are required to contain liquids or light gases.

JET ENGINES. Higher operating efficiencies —through higher thrust-to-weight ratios—are possible with beryllium in jet engine compressors. High strength levels, together with low density, make beryllium attractive for use in blading, shafting and discs. Titanium, long a staple in blades, is 2½ times heavier.



ASTRONAVIGATION. An astronavigational sextant and scanning telescope are contained in a single unit, with a beryllium housing and optical base. It was selected for high dimensional stability, light weight and excellent thermal properties. BERYLCO cooperated closely with the developer of this highly-precise instrument for the Apollo program, Kollsman's Space Division.

PRESSURE VESSELS. This sphere is a pressure bottle forged from beryllium. Projected application is for liquid rocket fuels. High strength at minimum weight was the design objective. This product is typical of what is being done today with the wide variety of forms in which beryllium is available.

Circle No. 38 on Subscriber Service Card

To get anywhere, you need the right connections

Your target may be over the horizon, three thousand fathoms under the sea, or deep within the core of the earth. Wherever it is, chances are Amphenol has already worked on interconnection devices in your problem area.

Severe environments? Check our connector performance in either the 5000° or cryogenic ranges.

Pressures? Many special Amphenol connectors are operating at 5000 psi under water. Others at altitudes of 825,000 feet.

Reliability? We are meeting some of the toughest quality control and quality assurance requirements in the aerospace industry. Example: newly developed Amphenol stretch cables.

Man-rated reliability is a way of life at Amphenol Space & Missile Systems. You don't have to order it. It's yours whether you require mass-produced subsystems or just one component. Whatever your stage of development we can probably help solve or anticipate problem areas.

Just tell us where you want to go. We have the right connections. Amphenol Space & Missile Systems, 9201 Independence Avenue, Chatsworth, Calif.

SPACE & MISSILE SYSTEMS Amphenol®

AMPHENOL-BORG ELECTRONICS CORPORATION

cables • connectors • hermetic seals • interconnections • components • systems and subsystems

Circle No. 39 on Subscriber Service Card

Tactical Needs Dictate Better Equipment

Multitude of requirements include smaller, more flexible transceivers and night vision instruments; lower cost missile guidance urgent

THE NEED TO IMPROVE electronics involved in limited warfare is growing even faster than the Pentagon's emphasis on such warfare.

The greater mobility and faster response time inherent in tactical conflict call for higher reliability, reduced size and weight, simplified maintenance or shorter repair time, and multi-functional operation. At the same time, there is pressure to increase standardization and cut unit costs.

In communications, there is a continuing requirement for smaller, flexible transceivers capable of very reliable performance over short ranges. Both manpack and vehicular systems must be designed for use in rugged environments. For large-scale tactical operations, there is a definite trend toward automatic switching radio networks—perhaps the digital random-access types now in development, although sophisticated single-sideband FM techniques are strong possibilities.

Somewhat further in the future is the almost certain use of military communications satellites for ship-to-ship and aircraft transmission relay. How they may be used in field operations, at least from division level downward, is not yet clear.

Ground (or surface) radar development will receive continuing attention, particularly systems offering more common usage, not only among services but on a multi-functional basis.

In addition, small portable field radars for detecting personnel and vehicles, and for locating targets for aircraft missile and other ordnance, must be even further improved.

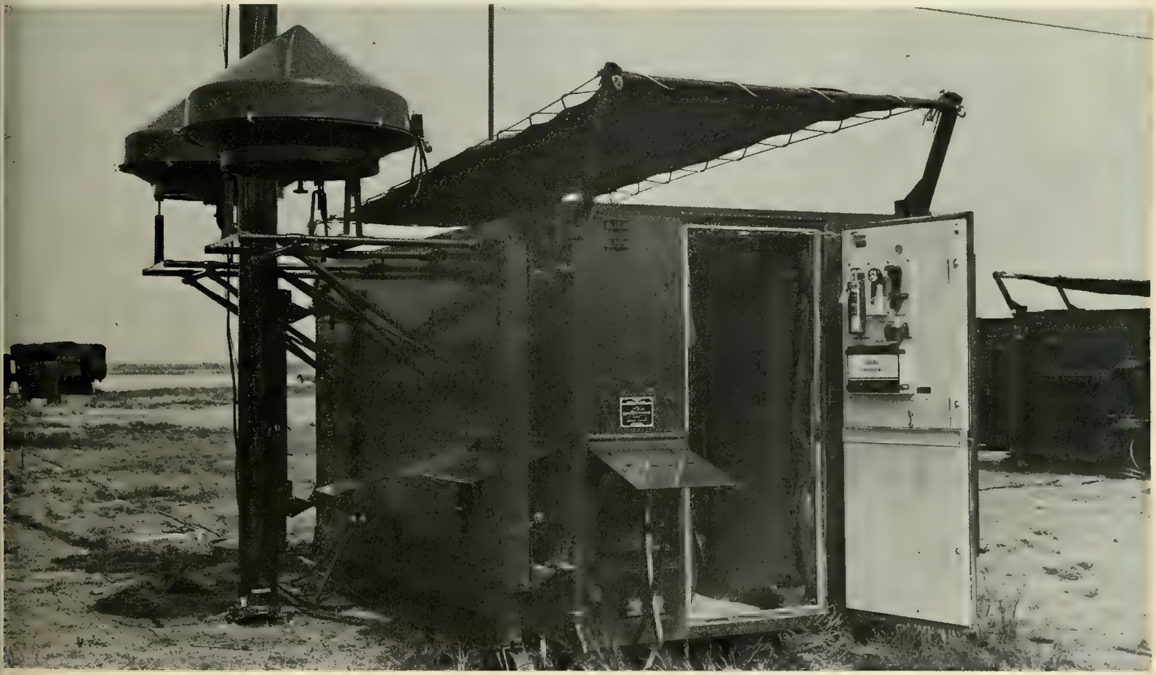
Two other areas in which intensive work will continue are night vision and low-cost missile guidance.

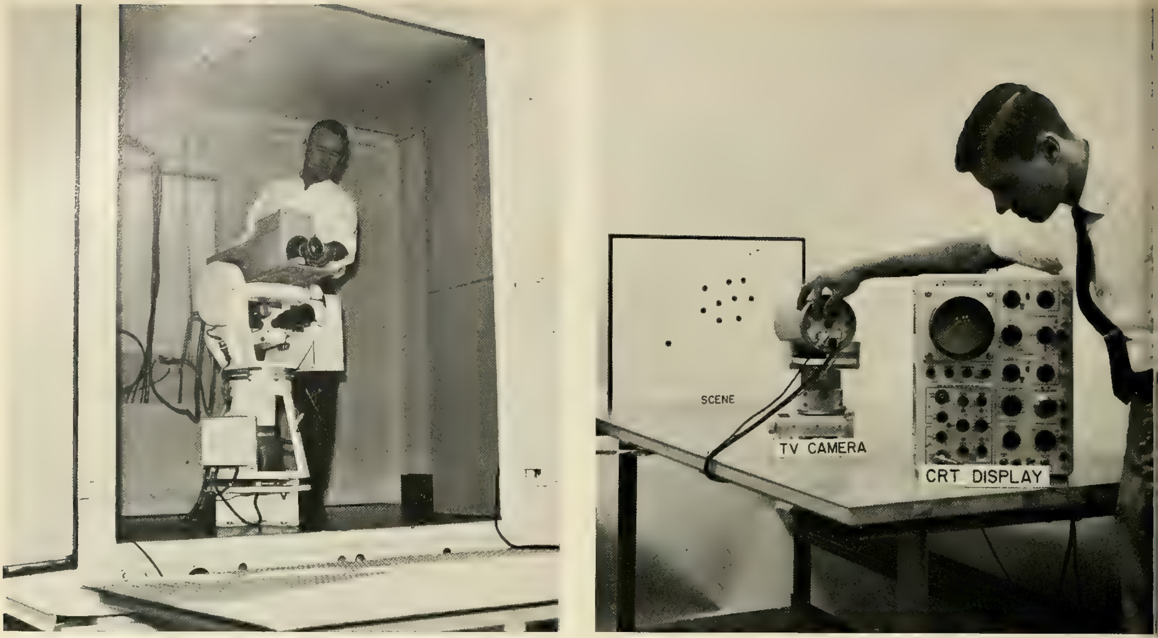
The first is being attacked from all angles, but the more promising approaches appear to be with low-light-level TV—image orthicons. One basic difficulty is the current lack of a broad industrial base in this field. The military says it needs high-resolution systems capable of wideband transmissions. Getting such performance with existing systems requires an intolerable amount of hardware.

Night vision instruments are needed not only for area surveillance, target acquisition or detection, and sector reconnaissance, but to permit safe and rapid ground vehicle mobility and aircraft let-down without ground assist.

Most pressing need for tactical mis-

TRANSCOM COMMUNICATIONS facility developed by Litton Systems, Inc., for the Air Force is typical of the current trend toward self-contained air-transportable systems for rapid set-up and operation. Transcom is a microwave high frequency system fully compatible with the Air Force Aircom system.





LEFT: Army Missile Command Electromagnetic Laboratory technician checks an optical tracking mount used in ballistic missile re-entry tests. RIGHT: AMC multiple target tracker. TV camera looks at a board simulating several targets and oscilloscope presents scene.

sile guidance is to lower system cost. In the past, the prime requirements have been high accuracy, fast reaction time, minimum size and weight. These features have now largely been obtained, but costs have approached the prohibitive level.

Finally, there remains an urgent need for better and broader applications of microminiaturized electronics in fully integrated systems. Again, cost reduction is a principal factor—but not at the expense of performance.

Thin-film and integrated-circuit design offer an answer, but much must be learned before all electronic needs can be satisfied with this approach on a total system basis. Many experts feel that designers are still penalizing themselves with outmoded design techniques employing a kind of black box-upon-black box subsystem fabrication rather than truly integrated systems making broader use of multi-functional circuits.

ARMY

R&D within the Army for future tactical electronic/optic systems appears to be concentrated within seven major fields: communications, surveillance, target acquisition, automatic data processing, aircraft electronics, image interpretation and guidance and control. Each of these is critical, and, within the yearly funds available, is under intensive development.

Army field communications have been, are now, and will be for some time to come, a serious problem. Reliability, self-jamming through local interference, the need for broad automatic switching networks (up through the division level), and more efficient use of frequency and channel allocations are aspects of the problem still awaiting technological progress. Elimination of wire communication below the division level is, of course, a prime goal—particularly because of the ever-widening rapid mobility of modern field units.

Random-access, direct-address field communications is still considered state-of-the-art. The Army's approach to obtaining such a system is one of step-by-step progress—slow, but more sure to pay off if the evolution supports further development. So far the Army has concentrated on determining the correct approach and establishing feasibility. It now has been authorized to continue its research (through Martin-Orlando) with limited breadboarding, propagation and noise factor studies.

Such a system, Army officials feel, is needed by the early 1970's, and should be available by 1973. Five years of RDT&E are estimated. They say eventual test by a full field division deployed operationally would be needed to thoroughly prove the system.

Accompanying RADA development is a growing effort toward digital communications systems. These offer significant advantages for anti-jamming, signal quality improvement, and better channel use. Arguments that digital systems will not come to the fore until 1980 are disputed by many in industry and in the military.

System size is still a major problem—as is compatibility with interfacing systems. A determined move toward digital systems will have to be based on NATO agreement as well as technological advancement. And costs still appear intolerably high for Army-wide application.

- **Surveillance, detection**—With regard to combat surveillance and target acquisition, one Army official said:

"If an area of concentration can be stated *per se,* it would have to be in the area of battlefield combat surveillance and target acquisition. This ability must maintain a lead over our weapons delivery capabilities within each time frame."

Even though a new man-pack area-surveillance and detection radar is going into operational use next year, there is strong feeling that considerable improvement in size, weight and performance is still needed.

The current trend toward "shoot and scoot" makes it obvious that a potential enemy will employ similar tactics. Thus, the need grows for faster-reaction, more accurate missile/artillery/mortar locators. Not only are present systems too large, but they tend to be overly complex. Simplified antenna systems must be produced.

Phased arrays have not yet been tried, but one DOD official says they

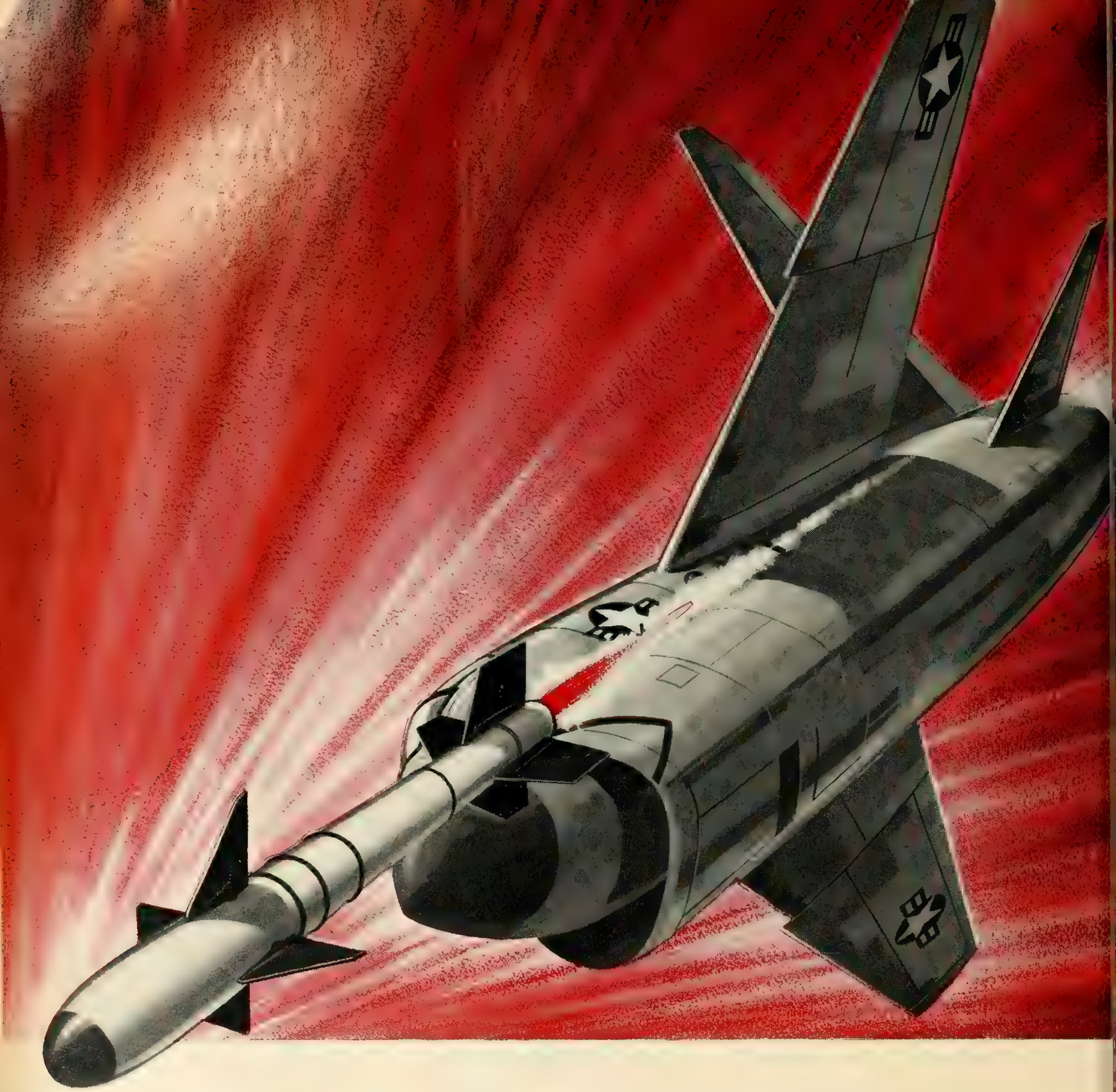
ARMS-LENGTH OBJECTIVITY

Here's how Vitro guarantees arm's-length objectivity, in the words of President Frank B. Jewett, Jr., as he testified before a congressional subcommittee conducting hearings on systems development and management: "It early became evident that Vitro's true value to the Navy was to supply completely unbiased engineering service in the missile system engineering function. As a result, in 1959, a Vitro policy was promulgated which states that the Corporation would not supply production hardware for any of the systems or missiles in which it performs the engineering coordinating service."

Vitro

VITRO CORPORATION OF AMERICA
90 PARK AVENUE
NEW YORK, N. Y. 10016

Circle No. 40 on Subscriber Service Card



Raytheon to produce Sidewinder 1-C guidance systems

New advanced guidance and control units for the Sidewinder 1-C air-to-air missile will be produced by Raytheon's Missile Systems Division. This is the Division which designed and produces the Hawk and Sparrow missiles, plus major portions of other systems in our nation's defense arsenal.

Raytheon won this large production award for the latest version of the Sidewinder under a fixed price contract in open competition with 18 other major aircraft and missile manufacturers . . . truly a recognition of Raytheon's proven experience and production capabilities.

The award of this contract was made possible by Raytheon's overall production capabilities, sound technical resources and efficient manufacturing facilities. Raytheon is proud to have been awarded this contract and looks forward to continued utilization of its research and production facilities for the advancement of missile technology. *Raytheon Company, Lexington, Massachusetts.*

RAYTHEON

Visit the Raytheon Co. exhibit at the Paris Air Show, June 11-21, 1965.

will be studied in the very near future.

For aircraft use, the Army is studying the Surveillance and Target Acquisition Aircraft System (STAAS). Employing a combination of electroptical/photo sensors and integrated supporting electronics, this system is scheduled for operational use by the early 1970's—probably in 1972.

Surveillance-drone sensing systems appear to be well in hand now, with no major new systems on the horizon.

Considerable effort, however, is being given to the application of lasers to ground and airborne surveillance and range finding.

- **Field ADP**—In the next two to three years, Army field automatic data processing will develop substantially. An ADP system is needed first for use at the field army level—capable of handling not only command and control, fire control and damage assessment in near-real-time, but other business management record functions such as personnel, supply and other administrative record and computational operations.

Many advances are needed to satisfy the severe environmental conditions that may be met in the field. So far, computers themselves are less of a problem than their ancillary hardware.

Future systems ultimately must be an integral part of communications systems, one official said. An operational system must be available by the early '70's, according to another.

An approach now under way will be tested by the Seventh Army, probably at the division level. Feasibility has been determined, requirements have been established. Program Definition Phase is next.

Peripheral subsystems, such as displays, are still puzzlers. The Army Tactical Operation Center showed what *not* to do, according to a DOD spokesman. Size and weight must be drastically reduced, he said, while reliability must be greatly improved. Also, ARTOC has shown that because of the peculiar needs of a tactical force, off-the-shelf equipment simply won't satisfy requirements.

- **Guidance and control**—The Army has launched a very broad effort to improve its missile guidance, not only in the inertial and electromagnetic areas but also for free rockets. The premise is that the cheapest guidance system is one that concentrates on aiming and eliminates flight hardware.

A new approach to free-rocket guidance is now being studied by theoretical mathematicians in an attempt to reduce a multitude of variables to a practical solution for field use.

Another major Army interest is a futuristic modular-type standarized missile capable of replacing at least *Sergeant* and *Pershing* and possibly *Lance*. A standard guidance module ring would be used with other functional stages added, depnding on the type of performance needed.

The Army already has studied a single guidance system for *Pershing* and *Sergeant*. It found, however, that the *Sergeant* guidance problem is considerably more difficult, due primarily to atmospheric variables and influences.

Another way to simplify guidance systems is to perform more of the guidance functions with better propulsion control. The *Lance* approach using the Autonet guidance technique is an example.

The Army is working intensely with strap-down inertial platforms—it will soon test three distinct methods in an attempt to find the best at the lowest cost. The two-degree-of-freedom gyro appears to be gaining in popularity for pitch and yaw control.

New guidance techniques are called for in the anti-tank missile area. Ability to fire, then move immediately is much desired.

(Fluidic guidance and control systems also are being studied for the anti-tank roles and for a Missile-A type system of five miles range. A two-degree-of-freedom pneumatic gyro is under development, as are improved regulators and pickoffs.)

Supporting electronics for Army inertially guided missiles remains problematical. More standardization is needed between *Pershing* and *Sergeant*, particularly with the fire-control computer. *Pershing* support systems are being redesigned to reduce size, but the relative immobility of both systems is a complication. Missile set-up and alignment takes too long. The time to set up a launcher again after firing is considered far too long. (An interim measure already being employed is to provide operational missile units with more launchers per battery.)

Army efforts to improve its air defense for front-line troops has resulted only in a series of compromises and project name changes (*Plato* to *FABMIDS* to *AADS-70* to *SAM-D*). Much of the problem lies with the target acquisition-tracking problem.

Sidewinder is being modified, under the name of *Chapparal*, for anti-aircraft use. *Hawk* is being studied and tested vigorously in an attempt to develop guidance techniques and advanced hardware to apply it to the anti-ballistic missile problem.

TV guidance techniques are being investigated heavily for target recognition in the visible region. Contrast and contour tracking methods are being considered, but centroids must be established to provide reliable target comparison data. Better vidicons and image orthicons are needed.

A laser radar approach using the near-infrared range is under study. One possibility is based on use of a laser as a tank illuminator for an optical homing missile.

Active IR guidance also is being considered, but a modulated low-power flare is lacking.

Passive IR systems capable of frontal attacks against low-altitude aircraft are sought, but background confusion remains a serious limitation for present IR systems.

One method may be to use IR acquisition supported by computer discrimination techniques and auto-signal processing for tracking.

- **Aircraft navigation**—Continued advances toward improved, simplified, reliable navigation systems are required

LAWSON ARMY AIR FIELD, Fort Benning, Ga., as is seen in photo taken by new Fairchild Space & Defense Systems' KA-60, 70mm panoramic surveillance system. Installed in the nose of Mohawk OV-1 aircraft, the camera scans 180 degrees to furnish extreme wide-angle view with 350% greater coverage than is obtainable with a frame camera.

Do you have need to know about IR?

If you have NEED TO KNOW and are in one of the 200 companies working with Infrared Indium Antimonide Detectors, we have something of value to tell you. We are qualified to produce high-sensitivity, reliable, liquid nitrogen cooled infrared detectors. These detectors operate under the photoconductive and photovoltaic modes. They are heat sensing or lack-of-heat sensing. Capabilities include military reconnaissance, missile guidance systems and commercial applications. Linear arrays and mosaics are also available.

NETWORKS
ELECTRONIC
CORP.

9750 De Soto Avenue · Chatsworth, California
Telephone 213-341-0440 or 213-873-6600

• THERMAL RELAYS* • INFRARED DETECTORS
• SELF-ALIGNING SPHERICAL BEARINGS

*A NASA RELIABILITY-RATED COMPANY
Centaur Program, December, 1964

MR. HOWARD W. DAVIS
Vice President, Infrared Division
Networks Electronic Corp.
9750 De Soto Avenue, Chatsworth, California

Dear Mr. Davis:
I have NEED TO KNOW about IR Detectors.

Name:________________

Company:________________

Address:________________

City:__________ State:__________

M&R

Circle No. 54 on Subscriber Service Card

NEW RECONNAISSANCE data-reduction shelters developed by Fairchild Space & Defense Systems under a $7.6-million Air Force contract furnish split-second intelligence on tactical targets. Three of the Image Interpretation Cells can be airlifted to any military theater within 24 hours aboard the C-130 Hercules transport.

for tactical aircraft. Considerable attention is being directed to the global VLF (Omega) navigation system, but it is felt that high accuracy is attainable only in restricted areas. Global accuracy is only moderate.

As with missile guidance, a breakthrough in inertial-system cost is sought for navigation. Also, pilots have less confidence in inertial systems than they do in radio techniques. Inertial systems do, however, provide self-containment and non-jamming advantages.

A new inertial navigation system has been developed (without regard to configuration size) and will be tested in Army aircraft over a six-month period.

AIR FORCE

With the steady increase in flight electronics requirements, the Air Force has directed a strong effort toward rapid development of microminiaturized electronics, particularly semiconductor integrated circuits. By maintaining a broad-based research effort and pressing the state of the art, Air Force officials correctly presumed early development of practical SIC subsystems and systems.

The payoff has begun, but the ultimate compensation will come when completely integrated avionics systems are configured and produced on a large scale. Tactical Fighter Avionics systems will provide all-weather and night weapons delivery capabilities with both air-to-air and air-to-ground missile and other ordnance devices.

To this end, The Air Force is continuing to press its electronics R&D.

Multiple high-resolution sensors are needed to improve AF recon/strike capabilities. And an Overland Radar/Airborne Warning and Control System capable of operating reliably under conditions of severe ground clutter is required.

• **Communications**—Because of its global commitments and its reliance on rapid response, the Air Force has been a heavy supporter of advanced long-range communications systems.

It currently is striving to improve over-the-horizon communications as a broadband basis.

Random-access techniques are being studied for close-support ground-to-ground and air-to-ground use. For limited warfare operations, the Air Force is studying use of airborne relay stations to provide early long-range circuits until more permanent ground stations can be airlifted, set up and placed in operation. Aircraft-to-aircraft relay also is being considered where necessary.

- **Radar**—Size, weight, reliability are the principal Air Force concerns in its radar development effort. Performance comes next.

For ground use, it is seeking a high-precision, very lightweight three-dimentional radar for command and control use in tactical operations. Such a system must also permit rapid set-up time.

For counterinsurgency, the service wants an ultra-lightweight system that can be broken down for manpack portage by from six to eight persons.

Combining radar and communications is the Air Force's Tactical Air Control System (TACS)—the 407/482L program. Operations Centrals are comprised of two self-contained air-transportable modules, one for radar surveillance and control and the other for communications.

The system is considered evolutionary and will be continually improved on a subsystem basis as required.

- **EW growing**—While little can be said concerning the Air Force's needs in electromagnetic warfare techniques and hardware because of security problems, AF officials indicate that ECM and ECCM requirements for tactical use are growing rapidly—particularly those for aircraft.

R&D and hardware will continue to be obtained on Quick Reaction Contract basis in an attempt to counter each recognized threat with a tailored solution.

One area receiving considerable attention is that of radiating devices and *Anti-Radiation Missiles (ARM's)*. Again, this is an EW game. Techniques apparently have been developed to confuse or misdirect *ARM's*. At the same time, more reliable radiation homing techniques are being sought.

- **Guidance**—The Air Force maintains a continuous effort to improve its weapons guidance system and techniques, with current emphasis on tactical missiles.

There is now a trend toward greater use of electro-optically guided weapons (missiles and bombs), but improved radar-homing seekers are still desirable for their all-weather capability. Hypersonic-operating seekers also have been stressed, but development has been centered chiefly on radomes.

NAVY

"Integrated" electronic systems is and will continue to be the byword in Naval electronics hardware development.

While it initially pressed integrated flight electronics—integrated helicopter avionics system (IHAS), integrated light aircraft (attack) avionics system (ILAAS), and A-NEW (integrated air-

HERE IS WHY
KORAD
IS YOUR BEST SOURCE FOR
LASERS

WHATEVER YOUR APPLICATION. Korad offers a complete line of LASERS — optically-pumped and injection types. You can choose the exact power range you want, from ¼ watt to 6 billion watts, and energy to 500 joules.

JUST PLUG IT IN. Each Korad LASER is fully assembled and tested at the factory. You buy a complete operating LASER — not part of a "do-it-yourself" kit. No extras to buy, match, and hook up.

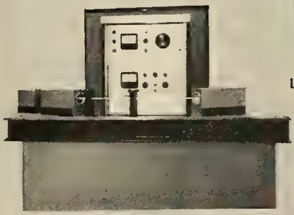
PLANNED LAB GROWTH. Every Korad LASER can be converted to giant pulse, higher power or more energy, later when you are ready to grow. Modular design throughout.

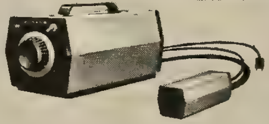
UNION CARBIDE QUALITY. When you buy a Korad LASER, you are secure in the knowledge that the reputation and overall know-how of Union Carbide Corporation is designed and built into every part of the LASER.

WAVE LENGTHS from ultraviolet to infrared.

LASER CALORIMETER

CW INJECTION LASERS


6 GIGAWATT LASER


PORTABLE YAG LASER

The technical team at Korad built the first LASER.
The design and manufacture of LASERS is Korad's only business.

SEND FOR LASER CATALOG & NEW GUIDE TO SPECIFYING LASERS

KORAD
UNION CARBIDE
A SUBSIDIARY OF UNION CARBIDE CORPORATION

2520 COLORADO AVE., SANTA MONICA, CALIF. 90406 PHONE: 213-393-6737

Circle No. 55 on Subscriber Service Card

DM AK24
TM antenna

DM AK20
TM antenna

Blade and Flush Telemetry Antennas

Dorne and Margolin, Inc. now offers a complete series of small missile and rocket antennas for VHF telemetry use. Both low drag blade and zero drag flush mounted models are available from stock. Some units incorporate heat shields for protection against aerodynamic heating up to 1400° F. Detailed specifications are available on request.

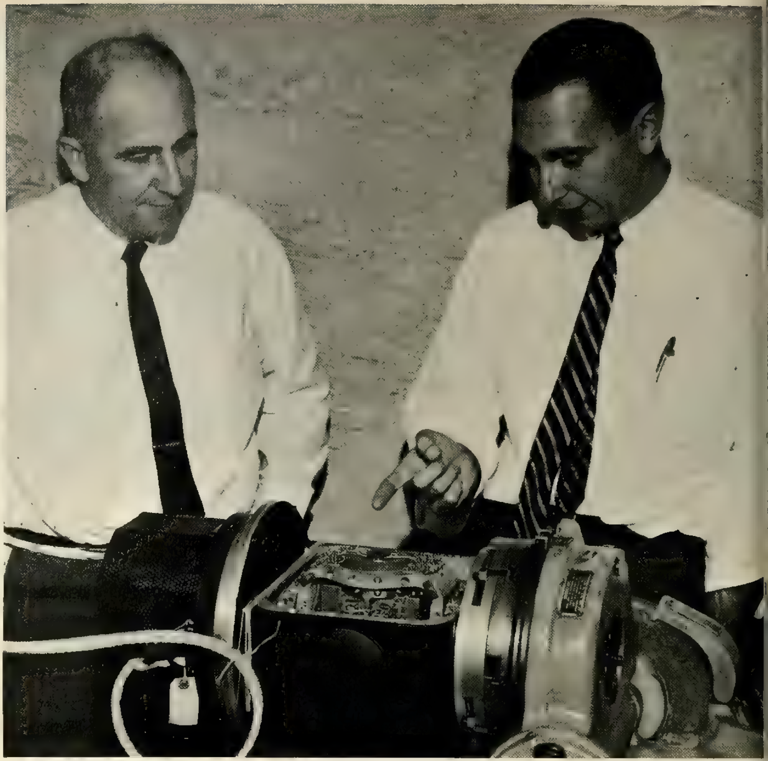
dorne and margolin
INCORPORATED

29 NEW YORK AVE., WESTBURY, N. Y. 11590
9730 COZYCROFT AVE., CHATSWORTH, CALIF. 91311

20 Years of Leadership in Aircraft and Missile Antennas

N. Y. 516 ED 4-3200 • TWX 516 333-2253
CALIF. 213 DI 1-4010 • TWX 213 341-4646

Circle No. 56 on Subscriber Service Card



NAVY'S NEW simplified inertial guidance system (SIGS). An experimental model of a fully automatic, self-contained missile guidance system is being developed by Norden for the Applied Physics Laboratory of Johns Hopkins University under subcontract to the Navy Bureau of Weapons.

borne ASW avionics system)—it has steadily extended the total system-design concept into other areas. The ASW ship integrated combat system, for example, tightly joins weapons and sensors within a single working design.

The trend will in time be extended throughout all future Naval electronic systems.

- **ASW systems**—Among the Navy's most urgent needs is that for radically improved acoustical sensing systems. The planned Active Planar Array sonar system, which uses a keel-like structure running from ship's bow to stern and essentially integrated with the hull, may point the way to employment of large numbers of transducers.

Three advanced sonars are now being considered: the submarine integrated sonar system (SISS) for fleet ballistic missile submarines; one to be compatible with nuclear attack submarines of the 1970 period; and a research-type system for deep-diving submersibles. The latter, while primarily aimed at oceanographic and other marine research efforts, may also provide new techniques for deep-water sonar deployment.

Unless a major sensor breakthrough occurs, however, much of the Navy's future emphasis will center on the signal processing side of detection, identification and localization. Reliable discrimination at long range continues to be a serious problem.

Research funds also will be available for development of techniques and hardware for magnetic anomoly detection. Present approaches are based on the use of optically pumped, highly sensitive magnetometers.

- **Guidance**—The Navy is pressing toward greater standardization of its surface missile systems with three distinct approaches: 1) a standard surface-to-air missile for replacing the *Terrier* and *Tartar,* capable of using their launch systems, and probably employing beam-rider radio guidance techniques; 2) an advanced surface missile system (ASMS) for use in the 1970 period and probably using radio-inertial guidance techniques; and 3) a point defense missile system, possibly based on an adaptation of an existing air-to-air missile such as *Sparrow III.*

The Navy is really seeking more versatile surface missile systems—missiles capable of use against all targets. For example, it has been seriously suggested that ASMS requirements include a counter capability against sea-launched

receive your personal copy of

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

every week

Examine this copy of THE WEEKLY OF ADVANCED TECHNOLOGY. You will quickly see why M/R is relied upon by subscribers for fast-breaking stories and complete technical editorial coverage of electronics, guidance, propulsion, advanced materials, ASW and ground support equipment. If you are not now a regular subscriber, it will pay to have your personal copies of M/R delivered regularly to your home, office, or laboratory on a weekly subscription basis.

FILL OUT AND DETACH CARD. CARD MUST BE FILLED OUT COMPLETELY BEFORE YOUR ORDER CAN BE PROCESSED.

YOUR SUBSCRIPTION INCLUDES THESE SPECIAL ANNUAL ISSUES:

MARCH
Annual DOD Issue

JULY
Missile/Space Encyclopedia Issue

NOVEMBER
Annual NASA Issue

ENTER MY NEW SUBSCRIPTION TO

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY

☐ 3 Years $10
☐ 2 Years $8.00
☐ 1 Year $5.00

Rates shown above are for U.S., Possessions, Canada and Postal Union Nations.

Other countries: ☐ 3 years $35 ☐ 2 years $25 ☐ 1 year $15. Air Freight to Europe: ☐ 3 years $40 ☐ 2 years $30 ☐ 1 year $20 ☐ Send bill later ☐ Check enclosed ☐ Purchase order attached

NAME..

TITLE OR POSITION..

STREET ADDRESS..

.... ☐ HOME? ☐ BUSINESS?

CITY.......................STATE.............ZIP #..........

COMPANY NAME..

DIVISION..

Subscriptions are limited to those in the missile/space industries or in related areas. Please fill out this card completely. Additional postage is required if mailed outside the U. S. A.

PLEASE INDICATE YOUR PRINCIPAL FIELD OF WORK

INDUSTRY
☐ Missile frame
☐ Power plants
☐ Electronics
☐ Support systems
☐ Components
☐ Consultants, R&D
☐ Missile base/range operations
☐ Propellants & Chemicals
☐ Metals, Materials

☐ Other ________________

GOVERNMENT
☐ Army
☐ Navy
☐ Air Force
☐ DOD
☐ NASA
☐ AEC
☐ Other U.S. Govt.
☐ Foreign Govt.

Subscription Cannot be Processed if This Information is Not Given

3 - 5

First Class
Permit No.
2455-R
Washington, D.C.

BUSINESS REPLY MAIL

POSTAGE WILL BE PAID BY:

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY

1001 Vermont Ave., N.W.
Washington, D. C. 20005

these missile engineers already know the value of missiles and rockets

"Missiles and Rockets is must reading every week."

President,
Missile & Space Contractor

"I want to keep up with the industry in which I am engaged. This publication contains information that I do not get elsewhere."

Analytical Engineer,
Rocket Equipment

"I like the magazine. It is different, it covers everything in as few words as possible."

Engineer, R & D, Missiles,
Radar Communication

"It keeps me up to date on new developments. All the information is condensed and you do not have to wade through a thousand pages to get a nickel's worth of information."

Project Manager,
Consulting Engineers

POSTAGE WILL BE PAID BY:

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY
1001 Vermont Ave., N.W.
Washington, D. C. 20005

BUSINESS REPLY MAIL

First Class
Permit No.
2455-R
Washington, D.C.

ENTER MY NEW SUBSCRIPTION TO

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY

☐ 3 Years $10
☐ 2 Years $8.00
☐ 1 Year $5.00

PLEASE INDICATE YOUR
PRINCIPAL FIELD OF WORK

INDUSTRY	**GOVERNMENT**
☐ Missile frame	☐ Army
☐ Power plants	☐ Navy
☐ Electronics	☐ Air Force
☐ Support systems	☐ DOD
☐ Components	☐ NASA
☐ Consultants, R&D	☐ AEC
☐ Missile base/range operations	☐ Other U.S. Govt.
☐ Propellants & Chemicals	☐ Foreign Govt.
☐ Metals, Materials	
☐ Other ______	

Subscription Cannot be Processed
if This Information is Not Given

3 - 5

Rates shown above are for U.S., Possessions, Canada and Postal Union Nations.

Other countries: ☐ 3 years $35 ☐ 2 years $25 ☐ 1 year $15. Air Freight to Europe: ☐ 3 years $40 ☐ 2 years $30 ☐ 1 year $20 ☐ Send bill later ☐ Check enclosed ☐ Purchase order attached

NAME ....

TITLE OR POSITION ....

STREET ADDRESS .... ☐ **HOME?**
.... ☐ **BUSINESS?**

CITY .... **STATE** .... **ZIP #** ....

COMPANY NAME ....

DIVISION ....

Subscriptions are limited to those in the missile/space industries or in related areas. Please fill out this card completely. Additional postage is required if mailed outside the U. S. A.

ballistic missiles. This system is expected to have a very short response time. Whether or not ASMS has an anti-SLBM role, it undoubtedly will be designed for both surface-to-surface and surface-to-air missions.

The needed point defense missile system will be used primarily as an antiaircraft gun replacement for small and auxiliary ships. Thus, guidance must be reliable but simple, requiring minimum training time.

SIG, the Navy's simplified inertial guidance platform now under development, may represent a major engineering breakthrough in the service-wide attack on system cost and complexity.

As presently designed, the inertial system already shows promise of ultimate production costs of less than $10,000 per unit. Due for open-loop testing this month aboard a *Sergeant* missile at White Sands Missile Range, the advance guidance device is expected to find application by the other military services. Besides the cost factor, interest is based chiefly on design simplicity and a 2-mil accuracy.

Another area of growing interest is the development of new guidance seekers and radomes capable of high performance in the hypersonic velocity range.

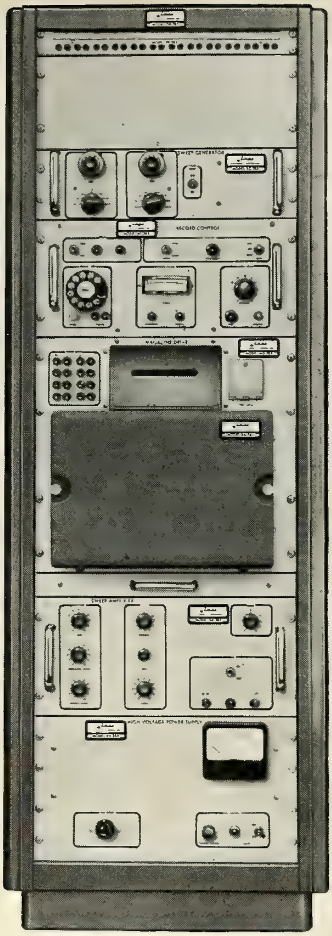
Also in association with the ILAAS is the development of an advanced air-to-surface fire-control system for air-launched ordnance guidance. The intent here is development of an integrated sensor/control system for improvement of target discrimination and all-weather accurate operation.

- **Other programs** — The Marine Tactical Data System, which includes an air control center, air operations center, and a data communications central, is now nearing completion. However, the Navy has indicated it will continue to press further microminiaturization of subsystems (TTY, radio and crypto) for air-control and operations centers. Improvements in radars also will be sought.

Advanced fixed radar techniques for search and height finding are being studied with a view to reducing or minimizing ECM vulnerability. Another hopeful approach in the radar field is with self-adapting radars capable of adjusting their operational characteristics to permit optimum detection and tracking of targets, simultaneously.

The development of long-range height-finding radars is being pressed. For long-range communications, the Navy is investigating means to reduce detection by a variety of techniques. One is based on the use of low-power directional transmissions relayed by military communications satellites.

For shorter range secure communicating, ship-to-ship laser use is being studied. ■



THE OR-285
THE CRT RECORDER THAT SETS NEW RECORDS IN HIGH FREQUENCY DATA ANALYSIS

This precision, high-speed Interstate OR-285 combines images from a high-resolution cathode ray tube with galvanometer traces onto single, moving 12-inch film or paper . . . providing a detailed, permanent recording for data analysis that up to now was impossible.

- Records at spot-image-speeds as high as 200,000 inches-per-second
- Resolution of 500 line pairs on 10 inches of recording media
- Cathode Ray Tube record is linear, flat to 20 kc in the swept axis, and intensity modulated via a 4-mc video amplifier, making it useful to 30-ips paper speed with a spot size of less than 4 mils
- Allows visual monitoring of the tube face while recording
- Provides record identification
- Designed with auxiliary modules—sweep generator, sweep amplifier, recording magazine and video patch panel—for wide range of applications

Interstate's OR-285 provides an extremely accurate method of signal analysis, pulse rate or pulse shape analysis, high frequency vibration analysis, telemetry signal analysis, high frequency phenomena display, radar visual recording, coordinated time base display and facsimile and video recording.

Read the full story of OR-285 in a new Interstate brochure. Write or check reader service card for your copy.

Interstate ELECTRONICS CORPORATION
707 EAST VERMONT AVENUE, ANAHEIM, CALIFORNIA
A SUBSIDIARY OF INTERSTATE ENGINEERING CORPORATION
Telephone: (714) 772-2222, TWX (714) 776-0280 • Worldwide Representatives

Circle No. 18 on Subscriber Service Card

ANOTHER ASPECT OF THE MARQUARDT MISSION

Marquardt Broadens Rocket Systems Capability

New Space Engine Laboratory Cited as Important Propulsion Milestone

When Marquardt dedicated its new space engine propulsion laboratory at Magic Mountain near Van Nuys, California, the completion was cited as "an important milestone in the Project Apollo program." Startup of operations at Magic Mountain now marks another significant extension of Marquardt's rocket system management capability.

MISSION-MATCHED FACILITIES

At the new space engine facility, Marquardt engineers are testing reaction control rockets and propellant systems for the Apollo Lunar Excursion Module. Advanced high energy fuels, including fluorine-based propellants, are also being handled at Magic Mountain to meet a broad range of future mission requirements. The Marquardt Jet Laboratories accommodate extensive environmental testing for airbreathing propulsion systems and rocket components. In addition, tests are being conducted at another Marquardt Research Field Laboratory for advanced propulsion and hypersonic regimes. The combined capability of Marquardt's facilities now provides testing of advanced aerospace systems, components, and fuels from sea level to above 185,000 feet.

MISSION-MATCHED TECHNOLOGY

Today, Marquardt is demonstrating its ability to assume rocket systems management responsibilities from concept to hardware. In meeting mission requirements, the company has documented many technological achievements on such programs as Advent, Syncom, the Project Apollo Service Module and Lunar Excursion Module, and the new Lunar Orbiter Vehicle. For example, Marquardt engineers were first to apply film-cooling techniques to radiation-cooled reaction-control rockets, utilizing fuel as a film coolant. Marquardt has also demonstrated several techniques for operating radiation-cooled engines with a secondary cold exterior wall, allowing application of such engines in submerged configurations on a spacecraft.

ADVANCED MANUFACTURING SUPPORT

Marquardt has implemented high precision manufacturing techniques, tooling, and reliability procedures in support of rocketry. Spin forged rocket cases, sophisticated ballistic missile nozzles, thrust chambers, propellant controls, and tanks are products of these modern methods. New contamination-free clean rooms assure the environment necessary to meet the stringent demands of aerospace requirements.

MEETING NEW CHALLENGES

Marquardt's quest for solutions to new problems is typified by efforts directed at future manned vehicle, satellite, and ballistic mission applications. Already pursuing studies on the Apollo-X, Marquardt is conducting extensive research on hydrogen-oxygen ignition, high density-high performance propellants, pyrolitic graphite and other high temperature materials, advanced cryogenic gels and slurry fuels.

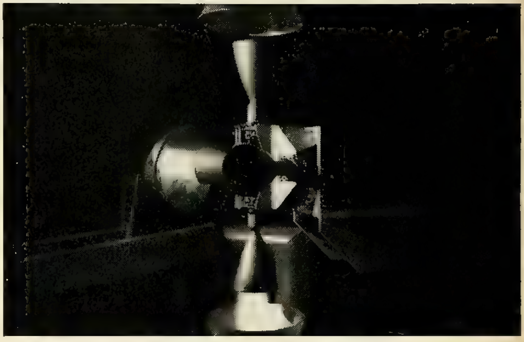
BALANCED CAPABILITY

Its work in the field of rocketry is but one aspect of the Marquardt mission. The company's engineering, manufacturing and facility complement is applied vigorously to support other major aerospace activity in airbreathing propulsion, space equipment, electronics, advanced research, specialized manufacturing, and industrial products. For information concerning the scope of Marquardt operations, write to J. B. Montgomery, President, The Marquardt Corporation, 16555 Saticoy Street, Van Nuys, California.

Engineers and scientists experienced in these or related fields will find it rewarding to discuss career opportunities with Marquardt, an equal opportunity employer.

Circle No. 35 on Subscriber Service Card

MARQUARDT ENGINEERS discuss status of reaction control rocket engine program in PERT meeting.



LEM ROCKET CLUSTER undergoes test firing at Marquardt's new Magic Mountain space engine laboratory.

EXPANDED CLEAN ROOM facilities assure environment to meet the stringent aerospace requirements.

THE Marquardt CORPORATION

CORPORATE OFFICES, POWER SYSTEMS
DIVISION, ASTRO—VAN NUYS, CALIFORNIA
POMONA DIVISION, INDUSTRIAL PRODUCTS DEPT.
—POMONA, CALIFORNIA
OGDEN PLANT—OGDEN, UTAH
SUBSIDIARY: AUTOMATION LABORATORIES INC.,
MINEOLA, L.I., NEW YORK

Another RD and E capability report from ALLIS-CHALMERS

First 28-volt fuel-cell system to pass 500-hour test at NASA!

Successful completion of this test demonstrated Allis-Chalmers capability to respond to RD & E challenges. The challenge was to fabricate and assemble two 28-volt, 1.8kw fuel-cell systems — subject one system to a 400-hour verification test and deliver the second system to NASA's Manned Spacecraft Center, Houston, Texas, within TWO AND ONE-HALF MONTHS after contract go-ahead!

The challenge was met on schedule. On arrival at MSC, the second system was successfully run by NASA personnel with assistance from Allis-Chalmers for 200 hours.

Next, NASA personnel took over and ran the system without assistance — through the four-segment load profile as specified — for 300 hours. Test time totaled 500 hours of operation under load, exceeding contract requirements and still operating within an acceptable performance range. Tests are continuing.

The test load profile varied from 480 to 1800 watts, a considerably more severe profile than would be expected during actual missions or qualification demonstrations.

Achieving design performance as predicted represents years of work . . . a result of constantly advancing fuel-cell capability:

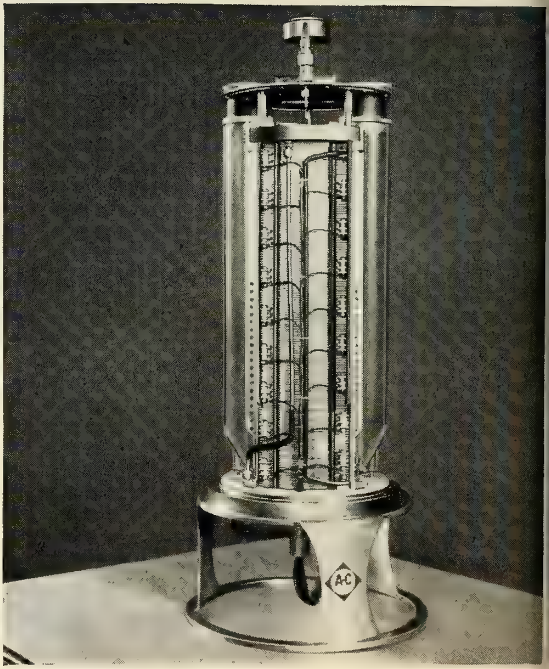
- First fuel cells in a land vehicle, 15-kw tractor, applied in 1959.
- First fuel cells to successfully pass zero gravity tests, Wright Patterson AFB, in 1962.
- First fuel cells "qualified for space" with the Air Force, in March, 1964.
- First fuel cells to power an underwater vehicle — Electric Boat Division, General Dynamics Star I submarine, in July, 1964.
- First 28-volt fuel-cell system to pass 500-hour test at NASA.

May we discuss your aerospace and defense fuel-cell application? Write: Market Development, Space and Defense Science Department, ALLIS-CHALMERS, Box 512, Milwaukee, Wisconsin 53201.

FUEL-CELL design for Aerospace and Hydrospace applications is but one of the opportunities open today for qualified scientists and engineers at Allis-Chalmers. For information concerning employment write to: Manager of Professional Placement, Allis-Chalmers, Milwaukee, Wisconsin 53201.

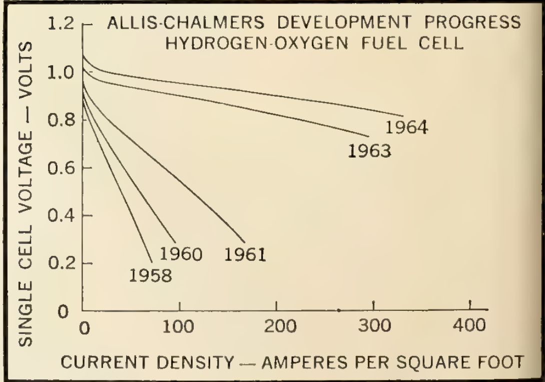
An Equal Opportunity Employer

ALLIS-CHALMERS



Allis-Chalmers 28-volt, fuel-cell system is the first to successfully pass 500-hour test at NASA.

Chart shows Allis-Chalmers fuel-cell technology has improved by an order of magnitude since 1958.



Circle No. 19 on Subscriber Service Card

Army Presses for Better Field Systems

Improved conventional sources favored for near future; other services leaning heavily on Army developments in area

DESPITE CONTINUING PROGRESS in development of fuel cells, nuclear power supplies and other unconventional energy conversion systems, the major gains expected in the high-priority effort to improve field-type power sources in the next five years probably will come through refinements in conventional batteries and engine generators.

The urgency of the requirement was pointed out in a recent directive from the Army's Adjutant General which reported that electrical power has become "a critical component" of major weapon systems for the field Army, affecting developments in target acquisition and location, fire control, surveillance, and communications, among other areas.

The Army says there is "an urgent need" for lighter, smaller, more reliable, quieter, and low-fuel-consumption devices. The directive called for an "aggressive R&D program" aimed at radical improvements in batteries, engine generators, and new energy conversion systems.

While the Army is certainly the largest user of tactical power supplies and has its own long-term systems needs in mind—including the ability to field higher power radars and communications equipments—the urgency of the situation is multiplied because other services, particularly the Air Force, lean heavily on the Army for technology and support.

Army support of this area has increased rather steadily during the past five years, primarily due to expansion in fuel cell research. This swing should continue, especially since the Army in FY '66 will begin to pick up fuel cell programs which were formerly supported by the Dept. of Defense's Advanced Research Projects Agency (ARPA) at a level of about $2.5 million.

Improvements immediately applicable to tactical systems are being sought through liaison between the Army's Combat Developments Command and the Materials Command. Supporting research efforts are centered at the Ft. Monmouth, N.J., Electronic Laboratories and at Ft. Belvoir, Va. A smaller effort is under way at the Harry Diamond Laboratories, Washington, D.C.

AMC scientists, in general, do not expect that any of the unconventional type conversion systems will replace batteries and engine generators for field army use within the next five years—with the possible exception of some very specialized missions for fuel cells. Beyond this period, the number of missions that fuel cells are apt to be introduced to is likely to expand.

The future of nuclear supplies in the Army at the tactical level is still very much in doubt and is the subject of a current Army evaluation. Other techniques, such as thermionic and thermoelectric system, while still the subject of research, demand major gains in efficiency and power output. They offer some promise for low power demands where silent operation is required.

GE 200-WATT fuel cell power source.

- **Batteries**—The Army's battery problems extend into both primary and secondary battery units. New work is expected to be focused on the secondary area in particular.

The present standard primary battery supply is the Zn MnO_2 Leclanche cell, which the Army characterizes as having a relatively short service life, requiring constant resupply; short shelf life, requiring refrigeration; and poor low-temperature operating characteristics.

One corrective solution, according to the Army, involves use of magnesium batteries which are expected to have twice the service life, shelf life, and better temperature characteristics. However, planners say that these cells exhibit some manufacturing problems, are more costly than the Leclanche cell, and also suffer from a delayed output characteristic. The latter problem involves a period of several seconds after turn-on in which full output cannot be achieved.

AMC scientists told M/R that another solution to the primary battery problem may be use of zinc-silver oxide units, which have very good characteristics but are "very expensive." In general, the Army is looking toward several more active materials—such as magnesium, silver, and cadmium—for both primary and secondary batteries, and is also very much interested in the air-type battery in conjunction with some of these materials. Scientists would like to upgrade battery performance to 100-120 watt-hrs./lb. from present levels, reportedly about 20 watt-hrs./lb.

The secondary batteries currently employed include conventional lead-acid storage batteries and nickel-cadmium units. The former are used primarily for vehicular application and for some elec-

SIXTY-WATT hydrogen-air fuel cell mockup.

EXPERIMENTAL VEST battery for use with radio set.

CAUTION NOTICE

tronic functions. However, these batteries are viewed as excessively heavy by the Army and also require venting. While the nickel-cadmium units overcome some of these objections. Army planners are not happy about their price.

In some secondary applications, the zinc-silver oxide storage batteries, which have the highest energy density, are used.

The entire area of rechargeable batteries is in for a major second look by the Army, since there are obvious logistics gains to be made by avoiding a constant field resupply. While some nickel-cadmium units are now in the field, the Army would like to reduce the weight to come up with smaller backpack sets, and also improve the design, or entire concept, of how these units are recharged in the field. There is some feeling that a fuel cell could be developed into an ideal, quiet, secondary battery charger for forward area use.

- **Handicaps**—Use of any power device in the forward area imposes many problems, not the least of which is noise. The noise problem, in addition to those of weight and reliability, is a major disadvantage with present engine generators. The Army is experimenting with a variety of closed-cycle external combustion engines, including steam engines, as a possible solution to the noise problem.

The weight and reliability problems associated with Army equipments in this area will be attacked primarily from the standpoint of introducing new microelectronic and modular packaging concepts, though the Army is aware that earlier innovations in miniaturization allowed the packaging of more components into a piece of equipment—with the result that the weight was still a problem.

In the fuel cell area, the Army is especially interested in the hydrogen-air cells which can operate with hydrocarbon fuel available in the field. Cells, in general, still look too expensive, they report, and still suffer from low power-to-weight ratios.

One key R&D goal is the elimination of expensive catalysts, such as platinum, in future low-pressure, low-temperature units. Once operation with hydrocarbon fuels can be readily achieved and higher power densities are reached, some scientists see fuel cells, possibly in 10 years, having missions extending into vehicle propulsion. This view does not go unchallenged, however.

Among the special applications that Army scientists see as more likely within a shorter period of time would be short-duration back-pack missions, 12-14 hours where power drains in excess of conventional batteries, possibly 500 watts, are required.

- **Nuclear outlook**—The Army's use

from crates . . .
to K-band reception
in
58 minutes

ADVANCED STRUCTURES MODEL 112
PRECISON PARABOLIC REFLECTOR

. . . whether in the field, aboard ship or at a fixed site all it takes to assemble is 2 men, 3 tools and 58 minutes.

Ease of attaining precision tolerances repeatedly in the field with the Model 112 series (12′-18′ dia.) fulfills the wide needs of satellite communications, precision tracking, radio astronomy and millimeter wave research.

ADVANCED STRUCTURES is the world's most experienced designer and manufacturer of quality parabolic reflectors used in the 3 to 300 gc frequency range. Among the many major programs that selected our antennas are: Nike-Zeus, Relay, Echo, Telstar, Syncom, Mariner, Lunar Orbiter and Apollo.

Whether your need calls for a tactical transportable antenna or a specialized space application write, or better yet call, ADVANCED STRUCTURES in La Mesa, California.

Whittaker
CORPORATION
ADVANCED STRUCTURES DIVISION
5159 Baltimore Drive, La Mesa, Calif. 92042
Telephone: (714) 469-0171

Circle No. 20 on Subscriber Service Card

WHERE CAN THIS MPU* FILL YOUR NEED FOR COMPACT POWER? Areas of current application for electrical and/or hydraulic power supply from this new Miniature Power Unit, include: tactical missiles, electronic countermeasure systems, portable power systems, and peak or emergency power supply. If you have application for up to 15-hp output from a unit of this compact size, we would be happy to discuss your requirements and mail you a brochure describing our MPU in more detail. Please contact Marketing Manager, Sundstrand Aviation-Denver, 2480 W. 70th St., Denver, Colo. * Miniature Power Unit

SUNDSTRAND AVIATION A DIVISION OF SUNDSTRAND CORPORATION
FACILITIES IN ROCKFORD, ILLINOIS AND DENVER, COLORADO

SUNDSTRAND

new design for power versatility!

Circle No. 21 on Subscriber Service Card

of nuclear power for tactical operations is not yet well defined, and the basic effort now is aimed at extending the technology.

A CDC survey, now in progress and due to be completed this spring, is aimed at outlining just what the future field needs will be. Once it is in hand, an attempt will be made to match the requirements of the users with the technology available to support them. There is little doubt that more power will be needed, and that nuclear units can supply large amounts of power. But the tactical environment and the requirement for portability is a major stumbling block.

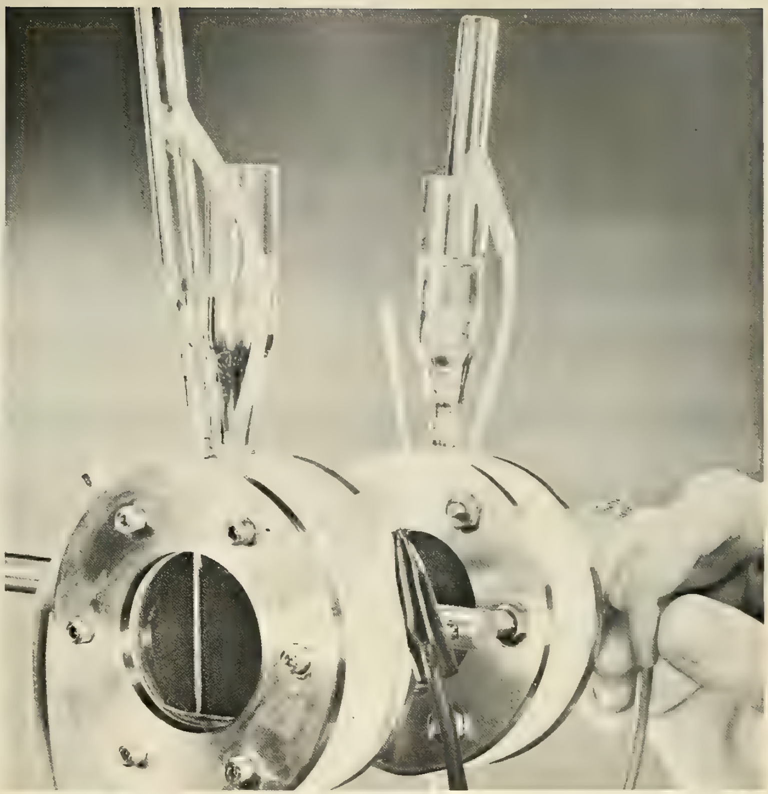
"We've got reactors," says one officer, but in comparison with high-speed diesel generators "they are big, heavy (because of shielding) and awfully expensive." They also involve longer periods for start-up and checkout.

The basic problem is that Army tactical power needs are not broken down into extremely large blocks, where nuclear power is most efficient. The need is for small packages, which are most difficult and expensive to achieve.

The Army has funded some work on a nuclear field radar supply, but has all but dropped the program. The project involves a gas-cooled 300-kw mobile reactor which has been under development in Idaho. The project for the reactor and getting it onto a trailer reportedly has a $4.5-million price tag, and the power needs can be accomplished far cheaper conventionally, the Army reports.

The other major on-going program is an energy depot study using the Military Compact Reactor, which got AEC support originally but since has been terminated. The Army, however, will carry on the depot studies which are primarily aimed at investigating ways of using nuclear energy to produce substitute fuel for a range of systems from internal combustion engines to fuel cells. There is also a possibility of using a reactor to charge storage batteries for electric drive vehicles.

Another possibility involves use of a nuclear depot in combination with new methods of power transmission. One approach involves microwave transmission of power on a large scale so as to utilize the efficiencies of nuclear generation, while at the same time allowing several users in a relatively small (20-mi.) area to pick off enough for their individual needs. Scientists see the possibility of using a several-thousand-kilowatt plant supplying many small users without the need for high-tension lines. Raytheon Co. has done much work in the development of microwave power transmission.



TWO GE hydrocarbon fuel cells connected in series can provide voltage suitable for operating small motors and other electrical devices.

- **Fuel cells**—Of the Army laboratories supporting AMC, the R&D efforts at Ft. Monmouth are the most directly applicable to the tactical power field. The lab is working primarily in heavy electro-chemical batteries, including new systems using a non-aqueous electrolyte and light metals such as lithium and magnesium as anodes in combination with a benzidine-derivative as a cathode.

A strong effort in fuel cells is also supported, mostly in the hydrogen-oxygen (air) cells. Two studies are under way on the use of hydrocarbons to be directly combusted in a fuel cell. This has been accomplished in the laboratory by General Electric, but much more work must be done before operational systems can be designed. In particular, less expensive catalysts must be developed.

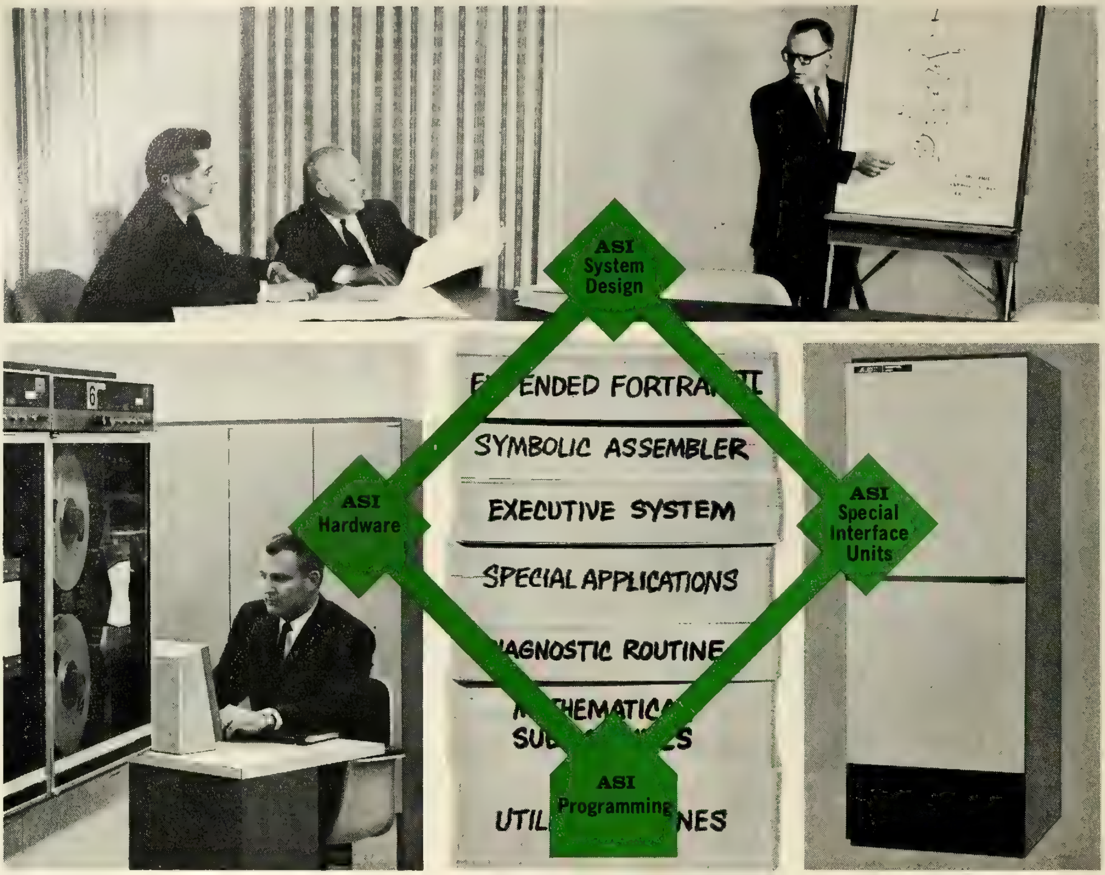
There is also a large effort in methanol-air fuel cells which the Army has now picked up from ARPA. This program, begun at Esso about three years ago, is seen as a good possibility for small sensor requirement, with demands under 1 kw and a need for quiet operation.

Two other programs in progress are concerned with the indirect hydrocarbon combustion for cells with tactical possibilities. One is a 5kw system being developed by Allis-Chalmers in which the hydrocarbon is reformed externally; the other is a Pratt & Whitney effort with Ft. Belvoir on an internally reformed process which Army scientists describe as a "very interesting approach."

Monmouth also supports some work at the General Motors Defense Research Laboratory in the use of thermal photo-voltaics, at the research level, for small (below 1 kw) power applications.

At HDL, miniaturized fuel cells able to put out milliwatts of power for very long periods are being studied. That lab is also researching new thermal batteries, able to operate at very high temperatures (700-1,000°C) using solid electrolytes and electro-chemical materials, and new component cooling and temperature-control devices using what is called the reverse thermo-electric technique.

Army effort in thermionics is very small, but the service is watching Air Force, NASA, and especially Navy, programs with interest. In thermo-electric research, too, the Army is largely limited to observing other service programs. It carries out a small research effort in magnetohydrodynamics at Ft. Belvoir. ■



From ASI's continuing program of new product development

ASI data systems experience covers all bases

In selecting a computer supplier for your integrated system, hardware is not the only criteria—systems design, special programming, and unit interfacing must be considered. ASI offers all of these with a notable plus—total customer service. From the time you define your problem, through design, interfacing, installation, and operation, ASI system specialists provide thorough, detailed support at NO ADDED COST.

Review the following major areas where ASI will benefit your system design.

SYSTEMS DESIGN—At no cost, ASI system specialists will completely analyse your required system in the definition phase before purchase. At this time ASI can tell you precisely what the system characteristics will be. Experience in the areas of data reduction, hybrid, real-time, and on-line systems design assure a balanced, efficient system.

STANDARD HARDWARE—The *ADVANCE* Series 6020 and 6040 computer systems feature high internal processing speeds such as 3.8 usec add and 9.5 usec multiply, rapid in/out rates, and a multilevel priority interrupt arrangement, which improve system application and operation. Other system-oriented features include—a choice of communication channels to meet your exact needs—expandable memory—over 8,000 control and sense lines—three index registers—"Programmed instruction" feature—direct access to memory areas—and real time clock.

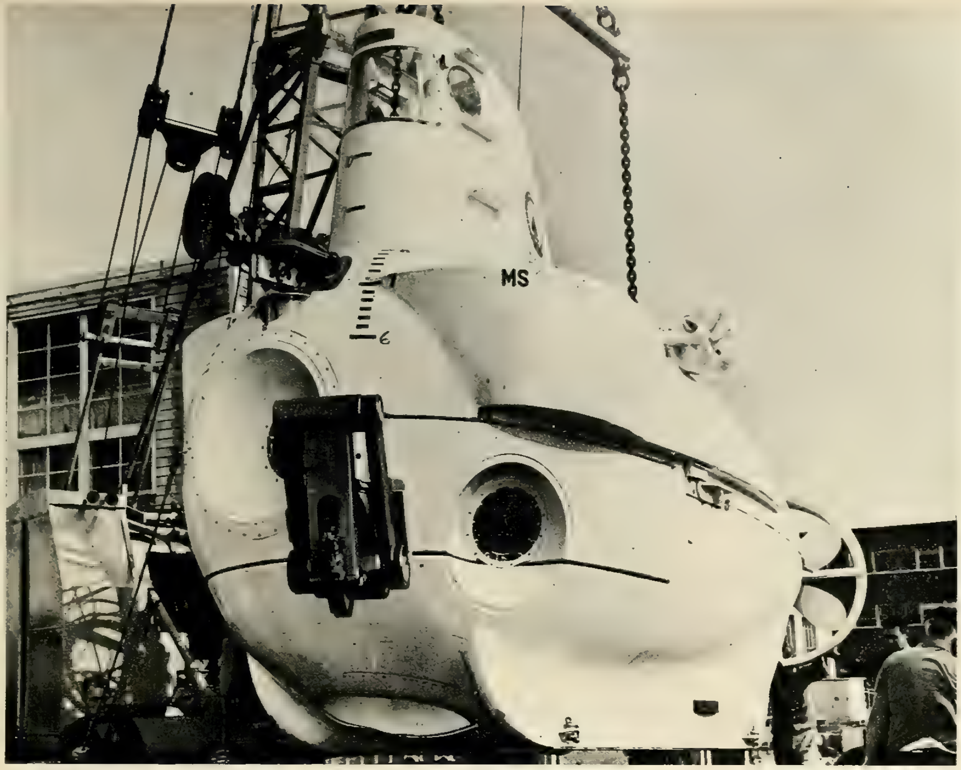
SPECIAL UNITS—ASI Engineering, at modest cost, will design and provide special interface units. In addition to typical units such as A-to-D and D-to-A convertors, multiplexers, etc., ASI also has provided "black boxes" for such applications as multi-channel analysers, remote station operation, photo-optical systems and others.

PROGRAMMING—To complement the standard software, which includes a one-pass extended FORTRAN II compiler and one-pass symbolic assembler, ASI applications staff provides special program preparation assistance. When requested, ASI will contract for total program responsibility on any *ADVANCE* Series computer system. Local field applications analysts are also available to aid in the daily operating routine as well as installation and operation of new programs. Call on ASI—it will be good for your system!

ASI

ADVANCED SCIENTIFIC INSTRUMENTS
DIVISION OF ELECTRO-MECHANICAL RESEARCH, INC
8001 Bloomington Freeway, Minneapolis, Minnesota 55420

Circle No. 22 on Subscriber Service Card



ALVIN, AN ONR-FUNDED deep-submergence vehicle, can operate down to 6,000 ft. for use in basic oceanographic research.

PART II/basic research

Military Objectives Spur Work

Fruits of basic research are apparent in today's weapons systems, but immediate goal remains increase in fund of knowledge

THE CONTRIBUTIONS of basic research to many of the tactical weapon systems in use today or foreseen for the near future are not difficult to trace. For instance, the studies the Air Force sponsors in non-linear differential equations can be used in the design of missile guidance systems, or in the stress analysis of high-speed aircraft.

Military administrators freely admitted such practical objectives during a series of MISSILES AND ROCKETS interviews. They maintained that otherwise there would be no point in the military sponsoring basic research.

Similarly, the Navy's work in physical oceanography, particularly in the study of wave forms and currents, bears on the hydrodynamics of torpedoes as well as on the design of sonobuoys. The Army's eagerness to pursue work in the aerodynamics of supersonic as well as subsonic bodies is easy to understand in terms of predicting the performance of bullets and missiles, and the flight of V/STOL aircraft.

Yet the immediate goal of basic research is to increase the general fund of knowledge. Scientists working for the military say there is no way to tell in advance where the knowledge will lead simply because there is no way to know what knowledge will be forthcoming.

So the military sponsors of basic research ride two horses: they pursue knowledge for its own sake, and at the same time choose projects that appear to offer the highest military payoffs. When scientific findings do come forth, the military tries to put them into practical applications such as tactical weapons as fast as their ingenuity will allow.

Although the benefit of basic research to tactical warfare is hard to ascertain at any given moment, there is little question of its value. Robert W. Morse, assistant Navy secretary for research and development, put it this way in testifying before Congress:

"Without basic scientific information, which an active research program routinely provides, these advances would not have been possible. Furthermore, advances in science occur over a long span of time, and a technical breakthrough today may well be based upon a chain of events leading back to apparently minor discoveries that took place in different fields at different times as much as a decade ago."

As an example, he cited the currently planned development of Integrated Helicopter and Integrated Light Aircraft Avionics Systems (IHAS, ILAAS), which rest on digital computer capabilities that did not exist ten years ago. Morse noted that naval communications today routinely make use of channels through which transmission or reception would have been impossible only a few years ago.

"It is part of our responsibility to review every segment of our research program to insure that we take advantage of incremental steps forward, and that we shape our program accordingly," he said.

The basic research arms of the Army, Navy and Air Force are spending about $150 million for contract and grant out-of-house work, chiefly to universities and other non-profit organizations. This figure is expected to rise about 10% for Fiscal Year 1966.

The Air Force and the Army see considerable increase in emphasis on the behavioral sciences, particularly as they relate to the activities in Viet Nam. The aim is to understand the drives, ambitions and other social and anthropological characteristics of people with whom the U.S. is concerned.

The physical or "hard" sciences will get a share of support roughly proportional to what they received in Fiscal Year 1965.

AIR FORCE OFFICE OF AEROSPACE RESEARCH

The Office of Aerospace Research, the Air Force's arm for basic research, is spending about $57 million annually in contracts and grants to non-profit organizations and industry. Oceanography is the only research science in which OAR is not involved.

OAR is spending another $24 million for in-house research, both to augment and supplement out-of-house research. Total OAR expenditures are expected to rise about 10% in Fiscal Year 1966.

Most of the contract and grant money is spent by the Office of Scientific Research (OSR), one of OAR's four major research organizations. In fact, OSR does no in-house research since this is the province of the other OAR research organizations.

These are: Cambridge Research Laboratories (AFCRL), located at L. G. Hanscom Field, Mass., a center for research in the environmental and physical sciences; Aerospace Research Laboratories (ARL), Wright-Patterson AFB, Ohio, with competence in physical, chemical and mathematical sciences; and the Frank J. Seiler Research Laboratory (FJSRL), at the U.S. Air Force Academy, Colorado, an in-house facility for research in the physical sciences, chiefly general and physical chemistry, fluid dynamics and flight mechanics.

"I'd like to see the in-house research (at OAR) build up in people and quality," Maj. Gen. Don R. Ostrander, OAR commander, told MISSILES AND ROCKETS. He explained that the Air Force has considerably fewer people working in basic research than the other services because the Air Force has nothing comparable to arsenals and service shipyards to draw on.

Ostrander said he would also like to move supervision of much of the outside research from the in-house laboratories to OSR. He hastened to add that he would not recommend that the laboratories completely divorce themselves from contract work since it provides important inputs to the in-house capabilities.

Contract funds have been moving toward OSR over the past few years. In Fiscal 1963, OSR spent about 60% of the OAR contract and grant money. This expenditure has gone up 2% every year since and it is expected to be about 66% in Fiscal 1966.

Asked if there are any areas in science that OAR will stress more than others during the coming years, Ostrander indicated the entire field of information sciences. In a wider view, this could be considered as cybernetics. It includes not only the classical information sciences, but also bionics, switching theory and a broad spectrum of associated work. "The Russians look at it this way, too," Ostrander said.

A top scientist at OSR said he expects more accent on the behavioral sciences, particularly as they relate to the countries and people the United States is presently most concerned with. He pointed to the problem of Viet Nam and the need to understand the nation, its history and anthropology. This is not a scientific problem from the viewpoint of many of the physical scientists at OSR; nevertheless, it is an Air Force problem considered amenable to the scientific approach.

● **General physics**—The OAR solid-state physics program has efforts that can conceivably be considered as being within the field of information sciences. However, they are not as easily identified as those in exploratory development.

Planned work in solid-state physics is organized under the headings of theory of solids; growth, purification and analysis; structural characterization; mechanical and thermal properties; electronic, magnetic and optical properties; and interaction effects and radiation.

Research in the theory of solids will also include studies in theory of crystalline solids; electronic structure of metals and semiconductors; collective modes and the many-body approach; cohesive energy in metals; ionic and molecular crystals; the work function and surface barrier; excited electronic states; and the electronic, magnetic, optical, thermal and mechanical properties of solids.

Electronic, magnetic and optical properties of solids are of prime importance in many materials applications. Research in this area will be on the problem of electron behavior in metal conductors; cooperative phenomena in solids, especially metals; the ferromagnetism of metals; semiconductors, with investigations of the details of band structures in various types of compounds together with impurity conduction processes; transport properties and energy state processes of electrons and holes in single-crystal semiconductors.

OAR's solid-state physics research is accomplished through in-house and contractual support at AFCRL and ARL, and at OSR through contracts and grants.

● **Mathematical sciences**—Two areas of OAR's present program contain efforts that can be classified as information sciences—applied mathematics and information sciences. The applied mathematics includes research in theory of automatic control systems, circuit and information theory and decision theory.

The information sciences studies are divided into eight functional areas: information system research, biophysical information systems, machine organization, artificial intelligence, information classification and extraction, information transmission, language and linguistics, and certain theoretical aspects of electronic techniques for information systems.

● **Electronics**—In electronics, OAR supports the Joint Services Electronics Program. The parts of this project coming under the broad heading of information sciences include studies in control system and feedback theory, pattern recognition, artificial intelligence, automata, adaptive systems, linguistics, speech, network and circuit theory, information and communications theory, coding, computer languages and the study of the properties of biological systems.

Another OAR program is a project in communication processes that includes the description, measurement and processing of human speech signals.

The major areas of OAR's future electronic research program are electro-optics, networks and circuits and communications theory.

● **Electro-Optics**—The combination of electrical theory and optical theory in those areas where the phenomena are similar has resulted in electro-optics. Diffraction of light from sonic waves in

STABILITY AT GRUMMAN

is not an abstract. It's a way of life. Some for instances. Our annual turnover rate is less than one quarter of the rest of the industry. 55% of our people have been with the company for more than five years. 37% ten years or longer. 19% over 15 years. Some engineers have been with the company since it started thirty-five years ago. A lot has happened since. We got up to our "fuselage" in military aircraft . . . in Anti-Submarine Warfare . . . in Early Warning . . . in Commercial Aircraft . . . in Space. Where will it end? Maybe on Mars somewhere. Professional verve with 'built-in' stability. That's the word at Grumman. Investigate challenging opportunities in the following areas.

The LEM (Lunar Excursion Module), the vehicle which will be used to land U.S. Astronauts on the moon, is a prime illustration of the long-range programs that enhance Grumman's characteristic stability. Extending through the 1970's, the LEM Program is regarded by many as the most ambitious technological endeavor of our times.

RELIABILITY CONTROL
- Reliability Engineering
- Reliability Test
- Maintainability Engineering
- G.S.E. Engineering
- Systems Reliability Engineering
- Component Parts

SYSTEMS ANALYSIS
- Mission Analysis
- System Synthesis & Analysis
- Data Processing Systems
- Systems Integration
- Control Systems
- Programming
- Systems Test Planning & Coordination
- Carrier Suitability
- Facilities & Services Systems Engrg.
- Sensor Systems
- Systems Simulation
- Programming Analysis

RF ENGINEERING
- RF Systems Analysis
- ECM
- Radar
- RF Communications
- EMC

VEHICLE ELECTRONIC DESIGN ENGRG.
- Aircraft
- Electronic Packaging

COMPUTER ENGINEERING
- Programming
- Computer System & Hardware Design

ELECTRONIC LIAISON TEST
- Radar
- Inertial Systems
- Electronic Field Engineering
- Digital Computers

SUPPORT ENGINEERING
- Circuit Design
- Logic & Switching Systems Analysis
- Digital Support Systems
- Servo Engineering
- Communications/Navigation
- Electrical Power Systems
- RF Engineering
- Propulsion Systems
- Cryogenic Equipment
- Environmental Control
- Structural & Mechanical Design
- Site Activation
- Handling/Transportation
- Calibration & Maintenance

SERVO ENGINEERING
- Power & Instruments
- Control Optics & Display
- Navigation & Control

FLIGHT TEST
- Instrumentation Systems Design
- Flight Operations
- Measurements & Transducers
- Instrumentation Installation
- Instrumentation Test Facilities
- Program Analysis and Support
- Ground Station Data Handling

(FOLLOWING AREAS, BOTH LOCAL & FIELD ASSIGNMENTS)
- R&D Electronics Flight Testing
- Facility Activation
- Pre-Launch Check-out Planning & Testing
- Spacecraft Mission Planning & Analysis
- Flight Development Test Planning & Analysis

THERMODYNAMICS & PROPULSION
- Heat Transfer & Thermal Control
- Rocket System Performance Analysis
- Fluid Mechanics/Gas Dynamics

COMPUTER SCIENCES (DIGITAL GROUP)
Programming Specialists (IBM 7090, 7094) for:
- Engineering & Research Applications
- Hybrid Simulations
- Real-Time Digital Simulation
- Information Storage & Retrieval
- Data Collection & Reduction
- Special Purpose Compilers
- Monitors, Systems Support
- Remote Console Systems
- Special Purpose Computer Support

STRUCTURAL DESIGN
- Layout/Design Aerospace Structures

STRUCTURES ENGINEERING
- Stress Analysis
- Structural Methods & Development

SPECIFICATIONS
- Preparation of Electronic Performance & Test Specifications (AFSCM 375 Methods; Configuration Management)

POWER PLANT & ENVIRONMENTS
- Environmental Control & Life Support Design & Test
- Fuel Cell Test
- Space Power Plant Design & Test
- Cryogenic System Design & Test

WEIGHTS
- Optimization
- Analysis

DYNAMIC ANALYSIS
- Environmental Vibration & Acoustics
- Space Dynamics
- Flight Mechanics

MECHANICAL SYSTEMS
- Armament Installation
- Fluid Power Systems Design
- Flight Controls

**To arrange an immediate interview, SEND RESUME to
Mr. P. M. Van Putten,
Manager Engineering Employment,
Dept. GR-86**

GRUMMAN
AIRCRAFT ENGINEERING CORPORATION
Bethpage · Long Island · New York
An Equal Opportunity Employer

Circle No. 33 on Subscriber Service Card

liquids may be used for direct display of radar targets involving conversion of signals from radio to acoustical to optical energy. Optical systems are valuable also for storage and cross-correlation of electronic data obtained in aerospace systems.

Expansion of these techniques for feedback and self-adapting controls of electronic systems, optical computers, light amplifiers require additional basic studies. Air Force interests center largely on the high rates of data processing and storage possible with these principles.

Focusing devices using the new coherent sources in the spectrum from microwave through optical frequencies require combinations of diffraction theory and new techniques of ray optics. Ideas such as the definition of transfer functions to specify the diffracted image in noisy and partially coherent signals should be developed together with methods for restoration of target information by spatial filtering and data processing.

Knowledge of the detailed structure of the focal or caustic regions of quasioptical systems offers opportunity for the design of shaped and phased exciting structures for correcting aberrations and increasing the volume and quality of information collected and transmitted by the imaging system.

In the areas of artificial intelligence, learning and adaptive and recognition processes, OAR research will include work on the basic aspects of strategic adaptive, and self-organizing machines, with emphasis on theorem-proving, problem-solving, and decision problems involving learning and adaptation.

● **Visual and auditory systems**—OAR efforts will include research on visual and auditory systems. Attempts will be made to reach conclusions about the networks and circuit mechanics for higher level concept formation. In addition, studies will be conducted of the response of individual neurons to stimulation by their immediate neighbors, using modern micro-electrode and computer techniques.

● **Biological and medical sciences**—OAR's objective in the biological sciences is to increase understanding of biological systems and to develop new concepts and theories to explain the structure, function and mode of operation from the molecular level through the cellular, tissue, organ and whole animal levels.

This project is intended to provide fundamental knowledge about living systems useful to all branches of science, technology and engineering. For example, neurophysiology research can be as useful to computer technology as it is to bioastronautics and to the man-in-space effort. There are efforts in the areas of neurophysiology, biophysics, ecology, endocrinology, molecular biology, physiology, biochemistry and photosynthesis.

ALLEN CAPSTAN SCREWS
SAFETY VALVE
VENTRICLE

ARTIFICIAL HEART PUMP at Army Ordnance Corps Harry Diamond Laboratories is an outgrowth of basic research.

OFFICE OF NAVAL RESEARCH

The Navy budget for basic research in Fiscal Year 1965 is $90 million. Of this, the Office of Naval Research will spend $57 million for contracts and grants. Another $17 million will go to the Naval Research Laboratory for in-house research. Total funding for Fiscal Year 1966 is expected to rise about 10% or $9 million.

The Navy describes three program areas in which it has a strong interest in encouraging basic research.

—Fields of science in which there is good possibility of payoffs to the Navy, particularly where the requirements of the Navy "differ in both kind and volume" from those of other agencies. Examples given: oceanography and allied marine sciences, fluid mechanics, structures, research on the upper reaches of the atmosphere, high-energy propellants and explosive chemistry.

—Fields of vital importance to the progress of naval technology and operations, but in which the Navy's interest is shared by others. Examples: electronics, the meteorological sciences, and microbiology.

—Fields that at present show little promise for naval exploitation, but which may eventually become highly significant to the service. Here, "sufficient awareness is required to identify these (fields) and promptly exploit them."

ONR is the Navy agency chiefly charged with fostering basic research. It is well known that much of this work is done for the service by universities and nonprofit research institutions. These organizations investigate fundamental processes of nature and new phenomena.

The industrial laboratories take the step after basic research for ONR. They support applied research and exploratory development, particularly to demonstrate the technical feasibility of a principle. ONR's policy is to support "research in previously neglected areas or where deficiencies in our knowledge could hinder the advancement of developments important to the Navy." To do this, ONR encourages investigators to submit their own research proposals.

● **Disciplines divided**—The basic research work sponsored by ONR is broken down into six disciplines, each managed by a corresponding ONR division. These are earth sciences, material sciences, physical sciences, mathematical sciences, biological sciences and psychological sciences.

The earth sciences division is understandably eager to promote any research that will help the Navy interpret and predict environmental conditions throughout the world, from the depths of the ocean to the outer reaches of space. With this information, military operations can be enhanced, and eventually the service might even be able to manipulate certain environmental factors, such as weather, to its advantage.

Appropriately, the division works in aeronomy, astronomy, atmospheric physics, geomagnetism, geography, geology, gravity, meteorology, oceanography and seismology. The work in oceanography is the most extensive. Here, ONR supports general international studies as well as highly concentrated ones.

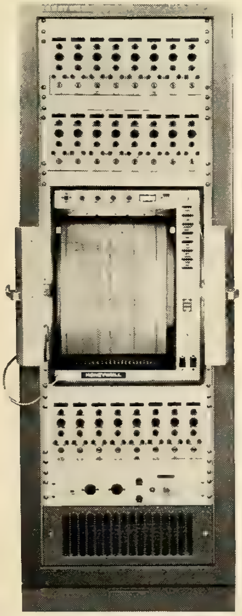
MILITARY/ AEROSPACE BUYERS:

Check these 11 ways Honeywell simplifies your data acquisition procurement.

Honeywell's experience in doing business with military and aerospace buyers has made these 11 extra services a matter of course. If you're not getting this kind of service now, call a Honeywell data acquisition field representative at Orlando, Houston, Los Angeles, Washington, Baltimore, Cleveland, Huntsville, or other aerospace-military center. Or write Mail Station 402, Honeywell, Denver Division, Denver, Colorado 80217. In Canada: Toronto 17, Ontario.

1. PRINTS For wired systems, Honeywell provides complete, interconnected wiring diagrams for the entire system, as well as provisioning prints for individual items.

2. CUSTOM ENGINEERING Each Honeywell data acquisition system, whether magnetic tape or oscillographic, is custom-engineered to your specifications. Prior to its arrival at your facility, you will have received your comprehensive Advance Information Book to speed installation, familiarization, and operation. Should you have requested advance shipment of rack hardware, mating connectors, handbooks, etc., they will also be on hand before your custom system arrives.



3. MIL SPECS Honeywell instrumentation meets many military specifications, such as for radio frequency interference. Ask about your particular MIL spec requirements... Honeywell will work with you.

4. QUALITY ASSURANCE Will Honeywell Data Acquisition Systems meet MIL-Q-9858A and/or NPC 200-3? Yessir; ask us about it!

5. SERVICE ENGINEERING Engineering teams, including engineering, application, manufacturing and quality experts, work constantly to solve your problems.

6. SPECIAL COLORS Panels can be finished to any colors in MIL standard 595 or to any other special color specification.

7. OVERSEAS PREPARATION Honeywell systems are packed for either domestic or export shipment to the exact packaging specifications that you require.

8. SPECIAL POWER Most Honeywell instruments are available for 120 or 230 volt operation at 50, 60, or 400 cycles.

9. MANUALS Complete technical manuals are provided for all individual instruments, as well as for all packaged systems.

10. PARTS LISTS All instruments and systems are delivered with complete parts lists; MIL SPEC parts lists available on request.

11. WORLD-WIDE SERVICE All systems can be Honeywell-installed, serviced, up-dated, and maintained throughout the world. Call us today!

DATA ACQUISITION SYSTEMS

Honeywell

Circle No. 23 on Subscriber Service Card

• **Oceanography**—The International Indian Ocean Expedition is a general study that was started in 1960 and will continue through 1965. The work has looked into the effect of monsoons on the ocean's circulation and the resulting distribution of biological life, as well as the general geology-geophysics of the area.

Should the Navy ever decide to station a fleet there, the information gathered through the expedition will be "invaluable," says ONR.

For work in physical oceanography, ONR is concerned with developing buoys for anchoring in deep water. This is one detail, although an important one, for getting data to predict the changing environment of the ocean. Indeed, programs such as buoy development are equally useful to the Navy's ASWEPS (anti-submarine weapons environmental prediction system) program as they are to pure scientific research.

These same programs are providing critical knowledge for convoy routing, amphibious operations, polar operations, mining, search and rescue, in addition to general strategic and tactical planning.

ONR is continuing to back studies in geology and geophysics. The results of such work for many years have provided foundations on which many Navy systems and weapons depend. Bottom bounce sonar, ARTEMIS and surveillance systems are prime examples.

Here are some of the future trends that can be anticipated in ONR's oceanographic program:

—more precise experimentation;

—data collection and analysis automated;

—buoys to play a larger role;

—need for deep-ocean research vehicles;

—more extensive use of aircraft, particularly for infrared work.

• **Material sciences**—The material sciences division—made up of metallurgy, chemistry and power branches—sponsors research that will bring about materials able to operate in strange and hostile environments. In particular, the work of the power branch stems from the use of chemicals and nuclear reactors as the sources of energy.

An extension of its mission has taken the power branch into research in magnetohydrodynamic (MHD) power generation and thermionics. With respect to the former research, the ONR power branch has three major objectives:

—experimental verification of non-equilibrium ionization under conditions of a motion-induced electric field;

—experimental measurement of all fundamental parameters governing plasmas characteristic of magnetoplasmadynamic (MPD) systems;

—investigation of non-mechanical pumping techniques peculiar to Brayton Cycle MPD systems.

The accent is on materials in the thermionics work, although some thermionic theory is simultaneously studied. Typically, RCA has a contract to investigate collectors and emitters of molybdenum, tungsten and rhenium at temperatures to 2,000°C.

• **Physical sciences**—ONR's work in the physical sciences is broken down into the physics branch, nuclear physics and electronics. Laser studies and infrared physics are of particular interest. The nuclear program looks into the makeup of nuclei and their interactions. Electronics includes studies of the propagation of electromagnetic radiation and background noise.

ARMY RESEARCH OFFICE

The Army Research Office (ARO), responsible for monitoring all of the Army's research, kept tabs on $90 million worth of basic and applied research in Fiscal Year 1965, and about $100 million of exploratory development.

Half the money, in each category, was spent for out-of-house work and half for in-house work at the various Army installations. The estimate for FY '66 is that the research budget will go up between 8% and 10%, identified as level-of-effort funding (which includes a cost-of-living increase).

Generally, the Army's funding for basic research is based on a level of effort in each major field. This work is conducted by the Army Materiel Command, the Surgeon General, Corps of Engineers and ARO as an operating agency. Thus ARO performs two functions: a staff function in planning and monitoring research for the Army, and an operational one.

ARO's work is broken into five disciplines through which the staff and operational functions are performed: environmental sciences, human factors (behavioral), operations research, life sciences (medical), and physical sciences (including engineering sciences).

An operating arm of ARO, known as AROD since it is located at Duke University at Durham, N.C., awards contracts and grants chiefly to universities and non-profit organizations for basic research in physical sciences. The function is similar to the Air Force OSR.

• **The raison d'etre**—The purpose of the Army research program, as with the other services, is to get basic knowledge that will further the efficiency of the service. For this reason, AROD has set up 40 miltary themes of high scientific merit for "oriented basic research." The orientation is intended to direct potential investigators into areas of research that hold the biggest probable payoffs for the Army.

HARSHAW
ELECTRO-OPTICS

- Basic Electro-Optical Materials: ADP, KDP, KD2P
- Orientation
- Optical Polishing
- Transparent and Aperture Electrodes
- Electro-Optical Device Development
- New Materials Development

Our development and production team is available to serve your needs in electro-optics.

THE HARSHAW CHEMICAL COMPANY
CRYSTAL-SOLID STATE DIVISION
1945 E. 97th St. • Cleveland, Ohio 44106
Phone Area 216 721-8300

Circle No. 24 on Subscriber Service Card

NEW

INSTRUMENTATION TELEVISION CAMERA

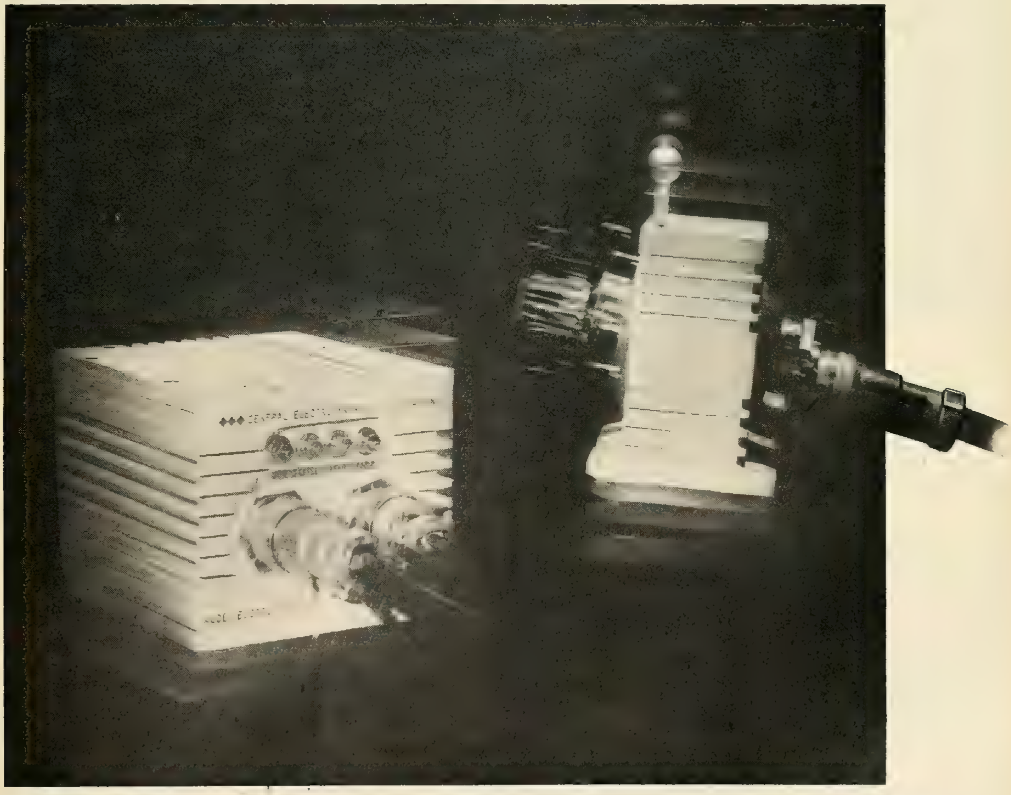
OPERATES IN EXTREME ENVIRONMENTS

The ED 6038 miniaturized instrumentation television camera was designed by General Electrodynamics Corporation to operate in the extreme environment existing within the engine compartment of the largest space boosters, such as Saturn. The high quality pictures produced during this severe environment will provide direct, real-time observation of events while they are happening.

This compact, light weight camera is available in a number of configurations with a wide selection of accessories from General Electrodynamics.

ENVIRONMENTAL CHARACTERISTICS:

20g RMS
60g RMS for 5 sec
20 cps — 2000 cps random
Shock: 100g for 11 ms
Altitude: Space environment
Acoustical Noise: +175 db
Temperature: —10°C to +71°C operating
—10°C to +125°C non-operating
Explosion Proof



G E C ®

GENERAL ELECTRODYNAMICS CORPORATION

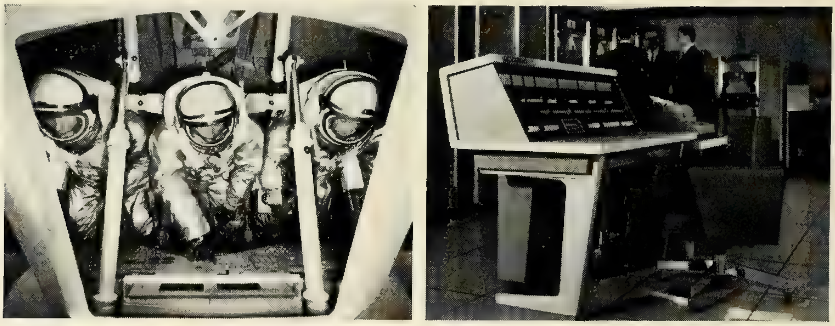
4430 FOREST LANE • GARLAND, TEXAS • BROADWAY 6-1161

Circle No. 25 on Subscriber Service Card

SPECIAL COMPUTER SYSTEMS PROJECT:

ACE

(ACE-S/C: Acceptance Checkout Equipment-Spacecraft)



Dual CONTROL DATA® 160G computer systems to check out the Apollo Spacecraft

At North American Aviation (Apollo command and service modules)! At Grumman Aircraft (Lunar Excursion Module-Lem)! At NASA in Houston! At Cape Kennedy! At General Electric! At all of these five locations identical CONTROL DATA 160G computer systems will insure completely compatible checkout procedures.

These checkout and acceptance tests approve or reject critical components to detect or warn of any failure right up to moment of launch. Each checkout system consists of *two* 160G computers. One performs high-speed data processing and diplays computed results according to a predetermined test plan. The other computer generates digital test commands and transmits them directly to command equipment on board the spacecraft.

This comprehensive "across the project" coverage is typical of the way CONTROL DATA serves users around the world, with hardware, software, support in depth — all oriented to the computer user and his methods. For details on how CONTROL DATA special systems deliver proven performance and complete reliability, contact your representative; or you can write direct to our Minneapolis address for information. Dept. M-35.

CONTROL DATA
CORPORATION

8100 34th AVE. SO., MPLS., MINN. 55440

Specialized computer systems from advanced technology, available today

31-64

The themes are broad in aspect and are themselves put into four priority groups, the first holding the most interest to the Army, and succeeding ones correspondingly less. Some of those in Priority I: ceramics for structural use; lasers; high-pressure and temperature processes used to produce new materials; research for night vision; studies leading to improved off-the-road mobility; mathematical analysis of non-linear systems; upper-atmosphere gaseous electronic processes; and aerodynamic studies at discrete flow rates to improve operations associated with missiles.

ARO is responsible for monitoring work of the Army Personnel Research Office (APRO), which for many years has done research in the proper matching of individuals and jobs. ARO also has overseas branches in Japan, Brazil and Germany for contract and grant work with foreign scientists.

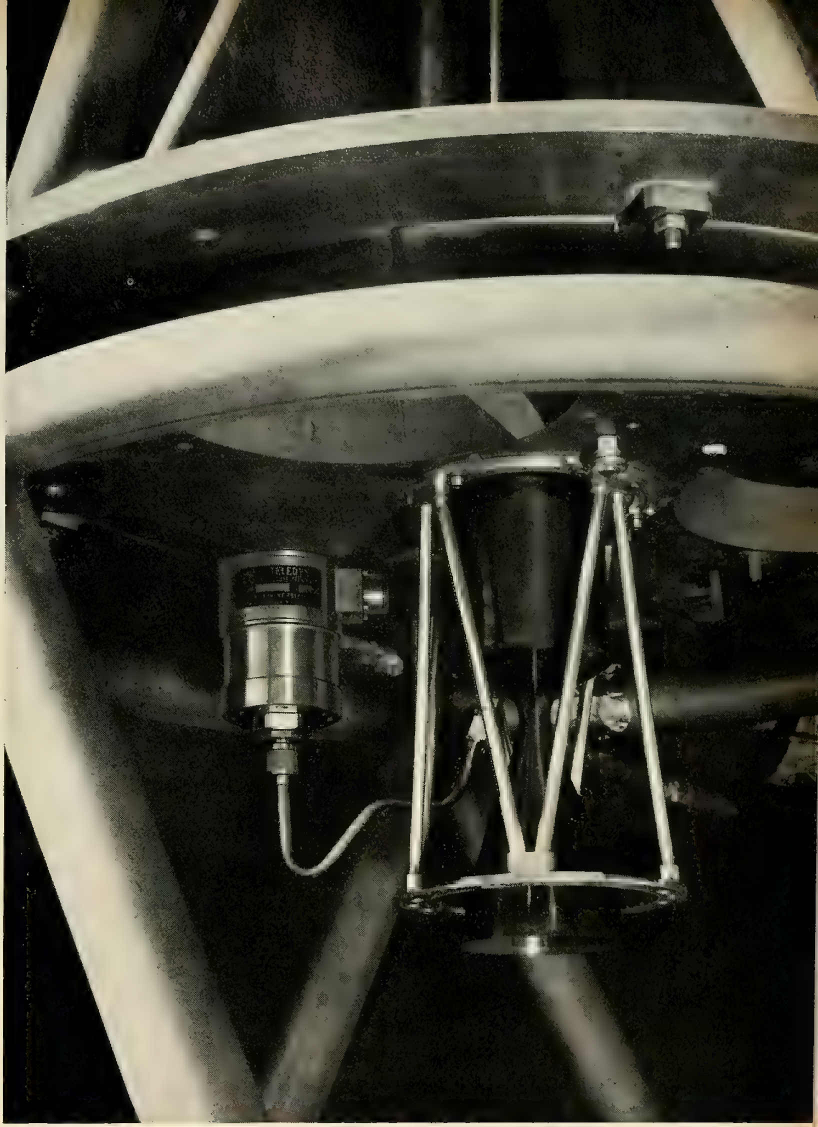
- **The "soft sciences"**—As with the Air Force research, the behavioral sciences will get highly increased emphasis in Army research. Viet Nam has taught many lessons, particularly that the U.S. does not know enough about how people in foreign lands will react under differing sets of circumstances. More information is needed about motivations, leadership and even the mechanics of political coups.

The Special Operations Research Office (SORO) of American University, Washington, D.C., is doing work for the Army on these "soft" sciences. Under the leadership of Professor Ted Vallance, SORO has already turned out several books giving detailed backgrounds and social characteristics of countries of interest to the service.

The Army for several years has maintained a team in Korea looking into the sociological aspects of the country. The Army hopes to be able to expand this work into other areas. In particular, ARO is interested in getting young and qualified Ph.D.'s with sociology or psychology backgrounds to work in Army soft sciences.

An example of the way ARO works through Army Commands is given by its association with Human Resources Research Office (HUMRRO). Directed by Dr. Meredith Crawford and affiliated with George Washington University, Washington, D.C., HUMRRO advises on special aspects of personnel training. Its principal customer is the Continental Army Command at Fort Monroe, Va. Although the work of HUMRRO is essentially applied research or exploratory development, as with basic research, ARO plans the work with the Command and HUMRRO and monitors it for the Army. At the same time, ARO maintains the level of the work in line with the money appropriated for it by the Defense Department. ■

Circle No. 31 on Subscriber Service Card

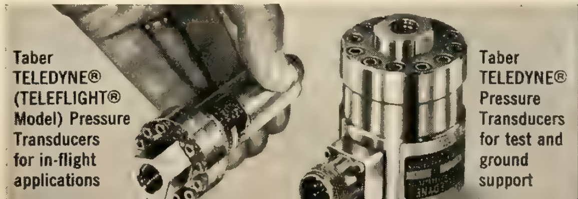


Taber Teledyne® used by JPL in testing Ranger motor

Shown above is a Taber Model 206-SA TELEDYNE® Pressure Transducer as it was installed on a Ranger mid-course guidance motor test stand at the Edwards Test Station of Jet Propulsion Laboratory. It was used to make precise measurements of rocket motor chamber pressures during flight calibration tests at simulated high altitudes.

Regularly selected to fulfill numerous aerospace requirements, Taber Bonded Strain Gage Pressure Transducers provide: high overpressure protection, long life, high reliability, infinite resolution, excellent stability, and low sensitivity to temperature, shock and vibration.

For detailed information, write: Aerospace Electronics Division, Taber Instrument Corp., Section 217, 107 Goundry St., N. Tonawanda, N. Y.



Taber TELEDYNE® (TELEFLIGHT® Model) Pressure Transducers for in-flight applications

Taber TELEDYNE® Pressure Transducers for test and ground support

Taber®

Cubic SECOR pinpoints it . . . nothing else can!

The ability of Cubic's SECOR to fix exact locations in space is unequaled. Where other systems only come close, SECOR, the world's most precise satellite tracking system, determines space vehicle coordinates with *pinpoint* accuracy.

Operational concept . . .

The heart of SECOR is a miniature 7-lb Cubic transponder. Carried in the satellite, this instrument acts as receiver-transmitter to three Cubic-built portable ground stations. These stations, located at known points on earth, make approximately 29,000 measurements or "ranges" during a typical six minute satellite pass. By using simple trilateration, SECOR does its work.

Speed with economy . . .

In tracking, SECOR saves valuable time and eliminates errors. Unlike photographic and Doppler systems, it collects data and gives readings simultaneously . . . without delay. Since its initial use during Atlantic Missile Range tests, the SECOR system has proved itself to be more accurate than costly radar systems.

Varied applications . . .

Currently the U.S. Army is using the all-weather SECOR system to plot and measure the earth with amazing speed and surveying accuracy.

Because of this accuracy, SECOR is an ideal system for range instrumentation or guidance.

In addition to guidance evaluation and ground charting, another important SECOR application is the precise instrumentation of satellite interception or rendezvous.

The implications of SECOR are important in all future measurement of earth and space. It will play a growing role in space and defense programs requiring extremely accurate location of objects.

SECOR is a product of Cubic Corporation, leader in the field of electronic measuring systems. For additional information, write: Chief Scientist, Cubic Corporation, Dept. D-141, San Diego, Calif. 92123.

CUBIC
CORPORATION
SAN DIEGO, CALIFORNIA 92123
SYSTEMS DIVISION

Circle No. 28 on Subscriber Service Card

part III

programs

Small-Caliber Weapons Get New Look

Fire support needs are bringing guns back into contention, though bulk of funding is in missiles; standards for missile systems tighten

THERE IS A MAGIC WORD in the Pentagon these days and that word is guns. After ten years as the poor relation, gun systems are being re-examined for their potential contribution to fire support of combat forces.

The Navy is studying small-caliber weapons as possible defensive weapons against both surface and air targets. Primarily, these would be armament for ships too small to mount the larger missiles and might possibly provide a point defense for larger ships (see Air Defense story, p. 101).

Marines are pushing the Navy for weapons capable of supporting amphibious landings. With the retirement of the battleship and its 16-in. guns, fire support for the Marines suffered a serious setback. For a time aircraft were considered adequate to the task. However, as one officer puts it, "you can only stack so many aircraft in a given amount of air space and then not always when you need them." Also, there are serious problems regarding an aircraft's ability to deliver ordnance on a target with pinpoint accuracy.

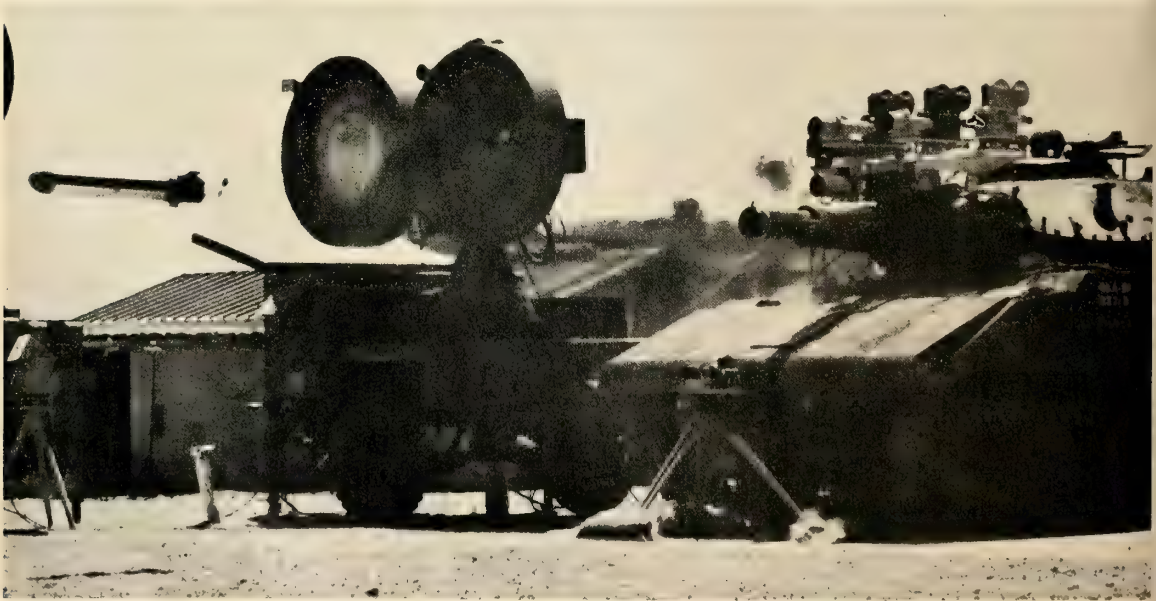
Consequently, the Navy is pressing several programs to boost the fire-support capabilities of Navy ships. One is a new, lightweight 175-mm gun with the accuracy required to destroy point targets such as pillboxes at long range. Another effort is the *Rocket-Assisted Projectile* (*RAP*) under development by the Naval Ordnance Test Station. This projectile, however, primarily increases the standoff distance at which ships can hit targets. In its present 5-in. version, its ability to penetrate hardened point targets is questionable. The major development problem so far is *RAP's* erratic performance.

The third approach, and the one favored by the Marines but not to date by DOD, is a missile system—the *Close-Support Assault Weapon*. This would be a system adaptable to *Terrier* launchers and would have a range of at least 30 mi. Since it would be inertially guided until it reached the target area, one of the key questions is whether a low-cost, accurate inertial guidance system can be built.

Norden Div. of United Aircraft Corp. has developed and delivered to the Navy such an inertial platform. Still to be determined is whether it can provide the required accuracy. An answer should be forthcoming from scheduled flights of the system aboard *Sergeant* missiles at White Sands Missile Range, N.M.

There appears to be little enthusiasm for the close-support weapon, however, in DDR&E. As one official puts it, "they haven't come up with a good solution to the targeting problem." Basically, the Marine concept is to use the inertial system to deliver the weapon into a given cone of airspace and then to pro-

SHILLELAGH, shown being fired from the General Sheridan reconnaissance vehicle, is one of the most promising tactical weapons now entering inventory.



vide a terminal homing device. "This sounds like *LaCrosse* all over again," snorts a Defense research official.

The Marines admit that the two approaches are the same, but they note that the acquisition unit would not depend on a human operator to acquire the missile, but would perform automatically. In fact, Applied Physics Lab of Johns Hopkins has built a breadboard of such a device. Future developments should make it possible to home the missile into a target illuminated by a laser.

Ultimate solution to the close support of amphibious landings is likely to come from the *Advanced Surface Missile System* (*ASMS*). This system is presently planned to be capable of taking under fire surface as well as airborne targets. To be fitted on destroyers and larger combat ships, this would boost significantly the fire support that could be given to Marine operations.

- **Army guns adequate**—Paradoxically, the Army foresees no pressing need for larger-caliber gun systems beyond the 175-mm. There is a continuing effort to lighten and improve the accuracy of field pieces, but otherwise the new family of artillery pieces now entering the inventory is considered sufficient.

A new, lightweight, unarmored, self-propelled 155-mm howitzer is under study. In addition to the 175-mm gun, the Army is procuring a family of aluminum-hulled and diesel-engine-powered howitzers ranging from 105-mm to 8-in. A new round of ammunition for the 105 which will add some 3,000 meters to its range is also in production.

Whether the Army goes to combustible cases for its ammunition is more a logistics consideration than a development problem. One Army official feels that the switch to combustible cases will be made "as it becomes more desirable from a production standpoint."

In the future, new high-strength steels previously unavailable in the U.S. and still not available elsewhere, coupled with new concepts in recoil mechanisms and new fuzes, could spark a revolution in guns. No decision has been made to take this course, however, since funds in the limited budget are largely allocated to missile programs.

Guns could also make a comeback in the direct fire role, some Army officials contend.

- **Missile selling tougher**—"We have built the systems we knew how to build. Although we have a long way to go before we exhaust the potential of the guided missile, we must have a real reason before we begin a new system." This quote from Maj. Gen. John G. Zierdt, head of the Army Missile Command, is an accurate expression not only of the Army viewpoint but also of DDR&E's.

A prime example of a missile system which will have to prove itself up and down the line is *Lance*, the division support weapon which is to replace the *Honest John* and possibly the *Little John*. First firing of the missile took place March 16, but as Secretary McNamara said in his posture statement, "further testing will be required before a decision can be made to place it in production."

Primary problems with *Lance* to date have been with the restartable motor which, in turn, affects the accuracy since, in the automet system, the guidance is tied to the precision performance of the engine. Accuracy is a *sine qua non* for *Lance*, which is to carry an advanced conventional warhead.

Even if *Lance* does achieve its Circular Error Probable (CEP) requirements, there is still one major stumbling block to deployment. In the words of one DDR&E official, "Can you find targets for it?" This problem of battlefield reconnaissance and surveillance is a general one for the Army. But the fact that, in DOD's view, it affects the deployment of *Lance* is in itself significant—and reflects a total approach that covers not only the performance of a weapon but its usability.

None of this is to say that *Lance* will not be deployed. It is rather to suggest some of the total systems questions being asked by DDR&E. In fact, in the context of replacement systems for *Sergeant* and *Pershing, DOD* officials look on *Lance* as "kind of a replacement for *Sergeant*." Freely translated, this means that there is no specific system under consideration as a *Sergeant* replacement.

Pershing, however, is another story. With the range limitations on Army weapons "disappearing," a 700-mi. *Pershing* appears to be definitely under consideration. It is being termed a

DAYS OF JURY-RIGGING infantry weapons to Army helicopters are ending. Future rotary-wing weapons platforms will be specifically designed for that purpose.

"product improvement" program, however, and Defense officials talk in terms of a missile with improved propellants and grain designs as well as lightweight guidance. Although there has been no decision to develop such a weapon, "there are programs in being to improve *Pershing*." Most immediate concern is to boost the readiness and reaction time of the long-range Army missile.

- **To kill a tank**—To someone on the outside, it would appear that the Army has a multiplicity of anti-tank weapons under development. However, there is still general dissatisfaction with the degree of ability to kill tanks at long ranges and with almost a unit probability. "Key to the next generation of anti-tank weapons depends on guidance developments," in the opinion of one Defense official. Another sees the answer in both guidance and hypervelocity.

Shillelagh, which in general is felt to be a good weapon, has been criticized by the Germans for its slowness—requiring the gunner to sit there exposed until the missile impacts. A supersonic version of the anti-tank missile is now under development. Also, an extended-range *Shillelagh* is to be built with a range capability beyond anything the Soviets have. It is expected to travel many yards farther than the present model.

"We have just made a breakthrough in these weapons," is the context in which Defense officials discuss *TOW*. Primarily, what they are saying is that the kill probability has been increased for first round hits. This is principally due to the optical sight to which is slaved a control system in the launcher, which in turn guides the missile by wire to the target.

MAW, the high-speed medium anti-tank weapon, is a question mark at the present time. Two approaches, one by McDonnell Aircraft and the other an in-house Missile Command concept, are to be fired off against each other this year as part of a feasibility demonstration. However, Defense officials refuse to say that the system will be developed since that "depends on refinements of *Shillelagh* and *TOW* production decisions."

In the light anti-tank category, the future is not at all clear. The *M-72*, the present weapon filling this gap, "is not really adequate for the job," says one official. But what should replace it is a wide-open question and depends on whether industry can come up with "some real good inventions." This general statement, in fact, applies to all anti-tank weapons.

"Requirements for missiles used in the direct fire role against a tank," according to Gen. Zierdt, "are similar to those for ballistic missile defense." Specifically, high-burning-rate propellants are needed to get the missile to the target quickly. First, however, the structural and aerodynamic problems produced by these high velocities must be solved.

A laser illuminator used to guide a missile to its target is a promising approach, as is the optical contrast seeker for indirect fire. Both of these concepts demand more development, however, and both must overcome environmental limitations and high cost.

- **Air-to-ground weapons**—*Hornet*, an air-launched anti-tank weapon which uses propulsion to achieve penetration, is fast approaching the day of decision on development. DOD and AF officials are impressed with the weapon. Originally, this was an unsolicited proposal by the Columbus Div. of North American

ABOVE: Lance, once it has licked its development problems, must face a unique series of questions as to its usefulness from a total battlefield systems standpoint. BELOW: Shrike, a most successful application of radiation homing, has led to the use of this type of terminal homing in the new ARM I.

Circle No. 32 on Subscriber Service Card

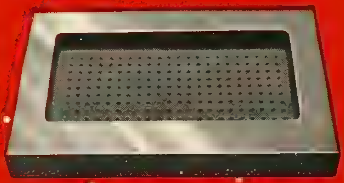
gently does it... with electrochemical machining by Ex-Cell-O. ☐ ECM is the fast and gentle way to finish-machine conductive aerospace materials such as those shown here. The tool (electrode) never touches the surface. Thus, there's no stress or tool marks, no burrs or heat checks, no distortion in thin-wall sections. A consistent finish within 3 to 10 micro-inches is possible, depending upon material. ☐ Most difficult configurations can be met in a single pass because ECM permits three-dimensional machining. Result: Ex-Cell-O helps you reduce lead time on experimental and prototype models, saves you valuable time on production runs. And accuracy meets the severest aerospace requirements and mil-specs. ☐ Got a tough space-age material that needs finishing? Now you know where to get the job done promptly, economically . . . and gently. ☐ *Flight and Space Division, Ex-Cell-O Corporation, 1200 Oakman Blvd., Detroit 48232.* 65-36 PD

Flight & Space Division XLO | **EX-CELL-O**

Integral airfoil vanes in turbine nozzle of Inconel 718 formed by Ex-Cell-O using ECM method. Band tolerances held within .004".

Blades of Udimet 700 with holes machined by Ex-Cell-O to precise tolerances using ECM method.

Fuel line cruciform of Hastelloy "C" has parallelism, concentricity and thickness held within .004" band tolerances by Ex-Cell-O using ECM.



Ex-Cell-O used ECM to drill 198 holes simultaneously in burner plate of 304 stainless steel, accurate to ± .0015".

MAN AND MISSILES FLY HIGHER, FASTER AND SAFER WITH PARTS AND ASSEMBLIES BY EX-CELL-O AND ITS SUBSIDIARIES. XLO

Aviation. However, it has been funded by the Special air warfare center at Eglin AFB, Fla., and feasibility firings have been conducted.

"There is general agreement," according to Pentagon officials, "that there is a need for something which falls under the capabilities of *Condor* and *Walleye*." Also, the electro-optical technique which would be used in *Hornet* seems "well in hand." The major question is whether something larger than *Hornet*, in the neighborhood of a weapon with a 50-lb. warhead, should not be developed. "Something this size would have possible application to a helicopter," these experts say, "but this depends on Army requirements."

Two Navy weapons scheduled to go into development are expected to be used by the Air Force and, eventually, the Army. These are *ARM I* and *Condor*.

A follow-on to *Shrike, ARM I* will capitalize on lessons learned from the earlier weapon. Its name an abbreviation for *Anti-Radiation Missile*, this weapon will be the first designed specifically for this mission. *Shrike* was an adaptation of an older missile, *Sparrow*, but that hasn't detracted from an excellent performance so far in operational evaluation. In fact, the "demonstrated capability of this missile has exceeded the original design predictions," according to the Navy.

ARM 1, on which the Navy has been conducting exploratory development, is funded at $6 million in FY '66. Accuracy is its prime requirement. Meanwhile, *Shrike* is expected to enter full-scale production this year and to be used by both the Navy and the Air Force.

Engineering development of *Condor*, air-to-surface armament for the F-111B (and probably the F-111A), is to begin in FY '66. Initially, this missile will employ the optical contrast systems developed by NOTS for guided bombs, such as *Walleye*. Accuracy of *Condor* is to be measured in CEP's of 10-15 ft. Additionally, the *Walleye* is expected to provide the same type of accuracy at much lesser cost per unit. *Snake Eye* is also to be procured as a low-level delivery weapon. With its retardation devices, it allows the delivering aircraft to pull away from the target before the weapons impact.

- **Quick-fix chopper weapons out**—Although the Army will spend some $33 million to procure 40-mm grenade launchers and machine gun-rocket launcher combinations in FY '66 for adapting to helicopters, the day of hanging infantry weapons on rotary aircraft is ending. The *Advanced Aerial Fire Support System* (AAFSS) is to complete its program definition and to go into development this year. Two contractors, Lockheed Aircraft Corp. and Sikorsky Aircraft, have been selected for the six-month studies.

Dash speeds of up to 220 knots are quoted for the *AAFSS*.

Also being discussed is a wide variety of weapons including high-rate-of-fire machine guns patterned on the Air Force six-barrel Gatling guns. Either *TOW* or *Shillelagh* will also be carried.

Several new elements of technology are being suggested for the *AAFSS*: advanced V/STOL or compound helicopter airframes, a new integrated helicopter avionics system and new fire control techniques.

Development of *AAFSS* is independent of the air assault division results now being digested by the Joint Chiefs of Staff. Defense officials say the air assault concepts are not expected to generate large-scale R&D requirements. Rather, the implementation of any JCS recommendations is expected to be based on present hardware—with perhaps up to $100 million a year eventually being spent in R&D.

However, DOD officials admit that this is speculation. No one knows what the JCS will recommend or how fast the Department will move to implement those recommendations.

A complicating factor in the *AAFSS* is the continued opposition of the Marine corps to the concept of the armed helicopter. The Corps is following the *AAFSS* program, but without much enthusiasm. Rather, the Marines are looking to the COIN/LARA (Counter-insurgency Light Armed Reconnaissance Aircraft) for support of transport helicopters. This aircraft is presently under development by North American and is expected to cost $18 million for seven prototypes. First flight is scheduled for this May.

The Marines consider the LARA not as a replacement for the light attack aircraft but rather as a supplement. Basically, they feel, it is a recon and *limited* close-air-support airplane.

- **What happened to ASW?**—A year ago, Defense officials were extremely concerned with the submarine threat; this year, Secretary McNamara told Congress: "the preliminary results (of a comprehensive study of anti-submarine warfare) do present a more favorable picture than we had before. . . ."

Although McNamara termed the results "by no means conclusive," what this study showed was that, in the words of one official, "by comparison our capability was good." Or, as another put it, "the conclusion suggested a greater degree of confidence that the fleet can do a creditable job in this area."

Basically, the study evaluated fleet exercises, enemy weaknesses, tactical analyses of probable avenues of attack, barrier defenses and damage-limiting forces. The conclusions were that the problem was not as severe as originally thought but that a continuing effort to update our ASW forces was required to keep ahead of the Soviets as the size of their nuclear submarine fleet grows.

A highly significant statement reflecting the confidence which DOD feels toward ASW was uttered by DDR&E Director Harold Brown to Congress: "At this time, our primary objective is attainment of the capability to kill high-performance, nuclear-powered submarines even with non-nuclear weapons where necessary. This objective appears within reach."

One of the major new weapons entering the inventory is the Mark 46, which ASW boss Adm. Charles B. Martell described as the first high-performance torpedo which is a match for deep-diving nuclear submarines. The Mark 46 is to be adapted to the *Asroc* as the payload and it can also be carried by fixed-wing aircraft, manned or drone helicopters and fired from destroyer torpedo tubes.

A second source for development of the Mark 48 torpedo has also been selected, and the first increment of these torpedoes will be procured in FY '66 for operational development. This weapon will be launched by either submarines or surface ships.

A new system which will enter the initial development stages is a submarine-launched anti-ship torpedo. Present efforts are being bent to solving guidance problems before development is initiated.

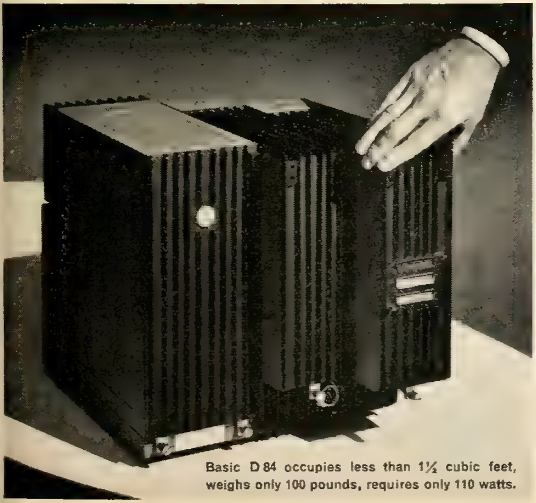
To eliminate the dependence on nuclear attack submarines for evaluation of ASW weapons and equipment, the Navy will initiate development of a new high-speed torpedo which can simulate the characteristics of the nuclear submarines.

Sea Hawk, the integrated ASW ship, has now been re-oriented into several advanced development projects and one engineering development. Propulsion is carried in advanced development with the ASW/ship Integrated Combat System, while the ASW Ship Command and Control system is carried in engineering development. Thus, the concept of Sea Hawk as a high-speed escort ship no longer exists.

Funding for ASW in FY '66 is $386.4 million—or 26.2% of the Navy's R&D budget. This compares with $312.7 million, or 22.9% in FY '65. An additional $73.8 from '65 was reclassified into other areas on the basis that it was not truly ASW money. ■

INTEGRATED CIRCUITS
+ MODULARITY

= NEW BURROUGHS D 84 COMPUTER



Basic D 84 occupies less than 1½ cubic feet, weighs only 100 pounds, requires only 110 watts.

Burroughs–T.M.

Meet a truly unique general purpose military computer, the Burroughs D 84.

Monolithic integrated circuits make it small, light, reliable and fit for the roughest ground, naval or airborne military environment.

Modular design allows it to exactly fit your application--and to expand as your requirements grow--without reprogramming.

Get the new D 84 technical brochure. Write or call Burroughs Corporation, Defense & Space Group, Paoli, Pa. Phone 215 NI 4-4700, Ext. 237.

Burroughs Corporation

Circle No. 29 on Subscriber Service Card

How on earth do you land on the moon?

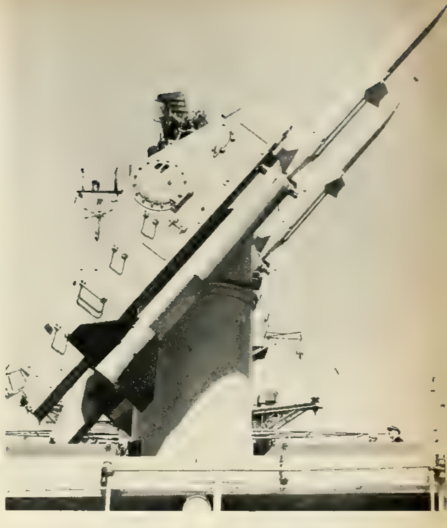
That's the problem Bell solved for NASA by creating the Lunar Landing Research Vehicle. Two of these spider-like moon-gravity simulators are already at NASA Flight Research Center, Edwards, California, engaged in research for future lunar landings and takeoffs. The gimbal mounted turbojet engine in the center of the vehicle is gyro stabilized in a perpendicular position at all times, regardless of vehicle attitude. Its automatically controlled downward thrust counteracts five-sixths of the earth's gravity in flight giving the pilot the "feel" of moon gravity. Reaction control rockets at the base of the four legs maintain altitude and control the attitude of the simulator in flight. This is another typical contribution of Bell science and engineering to man's conquest of space.

BELL AEROSYSTEMS Division of Bell Aerospace Corporation – A textron COMPANY Buffalo, New York

Circle No. 30 on Subscriber Service Card

PART III/air defense

Forward Protection Called Major Deficiency



TOP: Army's Hawk missile in its launcher. The weapon is also the only Marine ordnance in the SAM category. ABOVE: Navy Terrier SAM soon to be replaced. BELOW: Loki II sounding rocket may presage new forword area SAM design.

A MAJOR TECHNICAL and tactical problem facing U.S. military planners is forward air defense—an area confused by the complex relationships among men, machines, tactics and environment.

Secretary of Defense Robert S. McNamara pinpointed this problem in testimony before the House Armed Services Committee, citing the lack of forward area air defense as a major deficiency in our present military posture in Europe.

The cost-effectiveness approach used so successfully in developing U.S. strategic forces cannot be applied as easily to the whole area of limited, or tactical, warfare. The tactical area resists analytical processes.

The vast number of trade-offs and compromises within the totality of tactical warfare is forcing the Pentagon to concentrate on consolidation. Hence, the main concept is "product improvement"—and one official even calls this approach the key to tactical warfare.

The emphasis in evaluation is moving from the lab to the field. Pressure is being applied to get weapons accepted on a field-reliability basis—and then into the hands of troops sooner than has been done previously.

This trend is visible in the tactical air defense area.

• **Mauler illustrates**—The surface-to-air missile (SAM) *Mauler* is a case in point. *Mauler* was originally designed to go operational in Fiscal Year 1965 and provide the basic element in solving the forward air defense problem. Its progress is termed "disappointing" by McNamara and the system is destined for reorientation—stressing less sophistication.

Two major reasons for disenchantment within the Directorate of Defense Research & Engineering (DDR&E) with respect to *Mauler* are 1) its increased cost through the end of development, production and fielding the system, and 2) the combat experience being acquired in Viet Nam and Laos.

A key DOD official cites *Mauler* as a perfect example of the necessity for the program definition element introduced during the McNamara reign. *Mauler* never had this wringing out as an integral part of its cycling through a weapons systems life span.

Dr. Harold Brown, Director of Defense Research & Engineering, told Congress that *Mauler* continues to experience development difficulties. "Feasibility Demonstration Tests through March 1965," says Brown, "may well result in a decision to terminate development of *Mauler*."

The difficulties in the *Mauler* program are not so much an indictment of the program as conceived as they are a strong indication of the complexities of the whole problem of tactical air defense.

• **Reach exceeds grasp**—The cost effectiveness of any given weapon is closely tied to the tactical planning—and this planning, far more than strategic concepts, is subject to change.

A big factor here is that relevant military combat experience has not kept pace with systems developments. This and other considerations tend to make the analyses non-linear at DOD levels. Thus, the input factors cannot be merely added but must be treated as variables. DDR&E experts are looking for facts and not opinions.

With this state of mind, military planners and the men who control the R&D dollars invariably turn to Viet Nam.

The influence of the combat in Viet Nam is not as great as some critics indicate. Its net effect has been to cause a closer look at the realities of tactical warfare. This in turn is resulting in the product-improvement approach—a concentration on the uprating of the conventional and a stretching out of current concepts in development.

For instance, the high degree of emphasis on all-weather air defense in tactical situations is giving way to the realization that its maximum effectiveness is against an all-weather attack—and even the U.S. would have trouble mounting such an attack.

The trend towards getting weapons into the inventory by military acceptance through field tests quickly defines the urgent needs. These requirements often turn on mobility, response and equipment ruggedness rather than sophistication.

This then generates pressure for higher reliability—a longer mean-time-to-failure—and an equal pressure for ease of maintenance. This demand is coupled with combat realities—such as operation under fire.

In any event, all of these elements eventually would have been given the attention they are now receiving—the cyclic nature of DOD planning allows for this. Weapons now involved in operational testing for tactical air defense were conceived and implemented several years ago. They are now reaching the operational stages and the Viet Nam experience is merely being fed into the evaluation process.

While forward area air defense has become an urgent problem, according to McNamara, there are weapons systems in existence capable of adaptation to the problem—and these provide the "interim solution." There is, of course, the added element of defensive air power—and in some conceivable situations, this alone could reduce the effectiveness of a hostile air attack or could completely frustrate it.

• **Weapons approach**—The immediate solution to the gap left by the *Mauler* situation is being met in several ways. The first is the modification of *Sidewinder 1C* air-to-air missile for use on ground vehicles.

Christened the *Chaparral*, this program was first proposed to fill the *Sea Mauler* role. After the Navy Bureau of Weapons decided to go with the *Mauler*, the program reverted to its developers at the Naval Ordnance Test Station, China Lake, Calif. There it continued as an in-house air defense program.

The plan now is to push this concept through the few remaining stages of development and tests and then move it into the field.

A second program—also in existence for several years—is the use of 20-mm guns augmented with range-only radar fire control and mounted on self-propelled vehicles.

This new interest in guns seems to be the most immediate result of Viet Nam activity. There is a re-analysis of the vulnerability of high-performance aircraft to guns. DDR&E took note of the downing of U.S. aircraft with 37-mm manually trained, optically tracked antiaircraft guns. This activity bolsters the contention of some DDR&E officials who have maintained nothing has made the gun obsolete.

The last program thrown into the gap is the $11-million *Hawk* improvement project. An effort is being made to give this operational SAM system increased effectiveness together with an ability to engage some tactical missiles.

McNamara credits the *Hawk* improvement program as being a hedge against slippage or failure of the next-generation air defense weapons system—besides providing an interim solution to the *Mauler* void.

A longer-term solution to the air defense problem is being sought with some $10.0 million in requested funds. This effort will be directed at exploring more advanced approaches leading to the development of highly mobile, quick-reacting and, hence, survivable air defense systems.

Brown told the committee such an advanced forward area air defense system may well be a "clear air mass system." He did not elaborate.

In addition, some thought is being given to implementing a "Swizzle-Stick" missile—consisting of a weapon similar to the old *Loki* rockets in appearance but with greater speeds. Launched in groups with limited target acquisition equipment, these may prove effective against low-flying enemy aircraft.

The Army will continue to develop a new surface-to-air system aimed at eventually replacing both the *Hawk* and the *Nike-Hercules*. This program, initially started last year under the *AADS-70*, is now called *SAM-D* and will remain in the advanced development category for the time being.

SAM-D is under the direction of the U.S. Army Missile Command, Redstone Arsenal. Two contractor teams are currently working on competitive development of technical high-risk components. Additional system definition studies will soon be initiated.

Maj. Gen. John G. Zierdt, MICOM commanding general, says it will be decided later this year whether to continue the effort as advanced development or move it into a program definition phase.

Such a decision means a practical commitment to production and deployment by DOD—since the program definition phase includes this consideration.

Zierdt says that in *SAM-D*, the Army is looking for new means of target acquisition and new means of packaging to get the compactness required to keep the system completely mobile—a prime requirement for all Army missiles.

In addition, the missiles used as kill mechanisms in *SAM-D* must be small enough to be mobile, rugged enough to stand the bouncing of movement on the battlefield and fast enough to get out and make a kill before it's too late.

The *Redeye*—the smallest SAM system in existence—is now ready for release to full-scale production. DDR&E says the system—a 28-lb. shoulder-launched missile—has had a successful year of tests.

DOD is requesting funds totalling $3.5 million this year. About $0.5 million of this is slated to complete engineering on the missile and the remaining $3 million will go into the development of a follow-on weapon with more advanced performance capabilities. This probably means a boosted version of *Redeye*.

Redeye is a perfect example of the ideal SAM system—it is portable, its reaction time is all but instantaneous, and it can get as far forward in a combat situation as a man can carry a rifle.

There are other technical and tactical problems with *Redeye*. Some experts claim its performance is less than adequate. Others, more concerned with the command/control/IFF elements of close combat, fear its effectiveness against friendly aircraft. This latter is a touchy point, since the weapon is essentially under the complete control of one man in a combat situation.

The problem is best reflected in the prevalent informal slogan, "Shoot 'em down and sort 'em out later." This attitude does not seem to be a major problem in connection with the *Redeye* concept and use—it is mentioned to point out the complexities inherent in any tactical situation.

• **Naval air defense**—Air defense aspects of tactical Navy situations pose somewhat less of a problem than do land-based systems. Here it is possible to use rather sophisticated gear in the target identification, acquisition and guidance areas.

The backbone of ship-to-air defensive systems is the 3-T arsenal—*Tartar*, *Terrier* and *Talos*. Programs are under way to improve the existing systems and to achieve a state-of-the-art uprating by developing a standard missile and a long-range effort covering an advanced surface missile system.

Over $340 million has been reprogrammed since FY 1963 for the *Tartar*, *Terrier*, *Talos*, get-well project. This will continue into the next fiscal year with funds available from past reprogrammings.

The existing ship-to-air missile systems have been substantially improved during this reprogramming period. The kill probability and readiness rate of the *Terrier* have been increased by a factor of two and similar but less spectacular achievements have been made with the other two.

The SAM improvement program calls for the development of a new standardized missile designed for use with the *Tartar* and *Terrier* launchers.

U.S. ARMY
U.S. ARMY
U.S. ARMY
NIKE ZEUS

National Electric aims high

(FOR THE HIGHEST QUALITY IN THE PRODUCTION OF ROCKET MOTOR BODIES)

Quality is our watchword at National Electric! Through an extensive research and development program in rockets and missile components . . . the National Electric Works of H. K. Porter Company, Inc., has become one of the nation's major producers of rocket motor bodies.

With a staff of highly specialized personnel, National Electric has the capabilities and facilities to carry a project from engineering development of rocket motor metal parts through the manufacturing phase to completion. This experience guarantees outstanding performance in cost reduction and reliability on the most challenging problems.

For more information on our capabilities, facilities and technology in the areas of welding, metallurgy and production, write for our new booklet "Progress—National Electric Defense Products Facilities." Electrical Division Room 432, Porter Building, Pittsburgh, Pa. 15219.

PROGRESS
NATIONAL ELECTRIC DEFENSE PRODUCTS FACILITIES

PORTER

ELECTRICAL DIVISION
H. K. PORTER COMPANY, INC.

Circle No. 34 on Subscriber Service Card

SYSTEMS MEN NEEDED NOW IN FIVE VITAL WORK AREAS...

MITRE needs engineers and scientists who are interested in working on such projects as the NORAD Combat Operations Center, STRICOM's Command & Control System, Nuclear Detonation Detection & Reporting System, Range Instrumentation, and the National Military Command System.

We are looking for men who are systems oriented and who want to further broaden their interdisciplinary skills working on projects wholly in the national interest.

Immediate openings are available in Bedford, Massachusetts; Washington, D. C.; and Colorado Springs, Colorado, in the following work areas:

COMMUNICATIONS — Men with broad communications experience for work on the engineering of communication networks, range instrumentation, tactical air control, and survivable communications.

NUCLEAR WEAPONS EFFECTS ANALYSIS — Men with 2-4 years experience in the analysis of environmental effects of nuclear bursts on equipment, nuclear cloud obscuration problems and combinations of natural and nuclear effects on system performance.

SENSOR SYSTEMS & TECHNIQUES — Men needed to support theoretical and experimental programs on advanced radar and optical detection and tracking systems. Work includes feasibility and techniques analysis, systems synthesis and performance evaluation.

NATIONAL MILITARY COMMAND SYSTEM — Men for systems analysis and feasibility studies, communications systems analysis, systems design, integration, and design verification.

COMPUTER PROGRAMMING TECHNIQUES — Men with experience in specific fields, such as operations research, communications system analysis, computer software or hardware approaches, development and support of monitors, compilers, real time simulations, time sharing systems, etc.

If you have three or more years' experience and a degree in electronics, mathematics or physics, contact MITRE. Write in confidence to Vice President — Technical Operations, The MITRE Corporation, Box 208G, Bedford, Mass.

THE MITRE CORPORATION
An Equal Opportunity Employer

Pioneer in the design and development of command and control systems, MITRE was chartered in 1958 to serve only the United States Government. An independent nonprofit corporation, MITRE is technical advisor and systems engineer for the Electronic Systems Division of the Air Force Systems Command, and also serves the Department of Defense, and the Federal Aviation Agency.

The main objectives of this development program are:

—Increased reliability with less testing.

—Increased standardization between missiles.

—Improved performance against all targets.

—Increased range.

—Improved reaction time due to the elimination of warm-up time.

The Advanced Surface Missile program for the Navy is aimed at meeting the air and missile threat of 1970 and beyond. This program is in the pre-project definition phase and is undergoing exhaustive analysis of feasible system and subsystem components—directed toward an optimum in potential weapon system cost effectiveness.

The program will develop a dual-purpose (surface-to-air and surface-to-surface) weapon system having a very short reaction time and an ability to engage multiple targets in tactical situations.

In addition, the system must meet the practical demands of shipboard space in newly built destroyers and heavier vessels, while providing economical retrofitting into existing ships.

Technological and feasibility studies have been conducted by Raytheon, Boeing, Sperry Rand, General Electric, Westinghouse, RCA and Hughes into radars, information handling, airframe and missile design, ship design for weapon systems and all ancillary engineering fields required for a balanced system.

A special "Assessment Group" has been established to appraise the industry study output. This group includes both naval officers and technical experts, gathered from government and commercial organizations.

The Navy hopes this group will provide a sound basis for proceeding with the formal program definition phase—and the FY '66 request of $12 million will allow completion of program definition phase and initiation of full-scale development by the "best qualified" contractor.

Another $3 million is being requested for Navy Point Defense Missile systems. This need is defined as a rapid-reaction, lightweight, SAM system, widely applicable in small and auxiliary ships that cannot afford or physically mount the heavier systems.

This point defense system, if available, would in concept replace the anti-aircraft guns now used for self-defense on such vessels.

A variety of approaches leading to a short- and/or long-term solution are under study. The methods under investigation again reflect the consolidation and product-improvement trends so much a part of current DOD thinking

Circle No. 26 on Subscriber Service Card

HOW TO GET MORE INFORMATION

about products, capabilities, and literature in this issue

- Circle the appropriate numbers on the card.
- Fill out the card completely . . . title and company are a MUST.
- Tear out the card and mail (we pay the postage).

NAME ______________________

TITLE / POSITION ______________________

COMPANY ______________________

BUSINESS ADDRESS ______________________

CITY ______________________ **STATE** ______ **ZIP #** ______

missiles and rockets march 29, 1965

CIRCLE NUMBERS BELOW FOR INFORMATION ON PRODUCTS, LITERATURE OR ADVERTISEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125
126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249
250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274
275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299

please send me a subscription form for / missiles and rockets ☐

[illegible]

BUSINESS REPLY MAIL

POSTAGE WILL BE PAID BY:

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY
P.O. BOX 7653
PHILADELPHIA 1, PA.

HOW TO GET MORE INFORMATION

about products, capabilities, and literature in this issue

- Circle the appropriate numbers on the card.
- Fill out the card completely . . . title and company are a MUST.
- Tear out the card and mail (we pay the postage).

NAME______________________________________

TITLE / POSITION________________________________

COMPANY______________________________________

BUSINESS ADDRESS________________________________

CITY________________________STATE______ ZIP # ________

missiles and rockets march 29 1965

CIRCLE NUMBERS BELOW FOR INFORMATION ON PRODUCTS, LITERATURE OR ADVERTISEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125
126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249
250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274
275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299

please send me a subscription form for / missiles and rockets ☐

First Class
Permit No.
25357
Philadelphia, Pa.

BUSINESS REPLY MAIL

POSTAGE WILL BE PAID BY:

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY
P.O. BOX 7653
PHILADELPHIA 1, PA.

in these areas.

One solution is the possible adaptation of air-to-air missile systems to shipboard use. Another is the possible usage of components and technology from other service programs.

- **The broad problem**—While all of these evaluations of answers to the particulars of tactical air defense are in progress, DOD will soon be absorbing the results of a joint task force ordered to probe the whole question of tactical air defense.

This group, formed at McNamara's request last July, has been formed and is manned. Early this year, Joint Task Force Two commenced comprehensive testing of existing and new tactical aircraft, weapons and ordnance—including penetration against all forms of air defense weapons.

The output of JTF-2 will cover both the air attack and ground defense aspects.

The new drive for duality in delivery systems—demanding both nuclear and non-nuclear warheads on the same weapon—is reaching into the air defense area. Here it is more an effort to broaden the target ability of the system; this is applicable only in the advanced weapons concepts.

The main technological areas supporting the "interim" solutions to air defense are seemingly well in hand. There is no technical gap in sight. The major headache is money, and the emphasis is on a more effective bang per buck.

Propulsion development for tactical SAM systems—both liquid and solid—has reached the stage where an order-of-magnitude improvement over existing weapons systems is easily possible. This can be achieved in the same or smaller packages and this volume-limited requirement has been a prime target for propulsion firms and military labs for several years.

The major part of the technical problem associated with tactical air defense is target acquisition, identification and guidance. This is true for both the land services and the naval forces.

From a battlefield point of view, maximum mobility is the prime requisite. Mobility serves two purposes—bringing the system into action in a given area quickly and adding to its survivability.

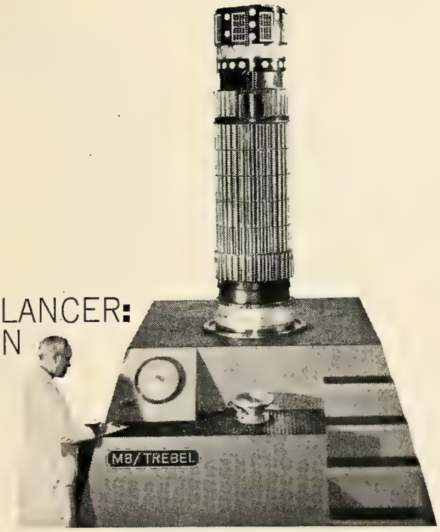
The propulsion element of the missiles involved in air defense and other phases of limited warfare cannot be easily broken down into types by military usage. The technology of strategic propulsion and tactical propulsion are essentially the same.

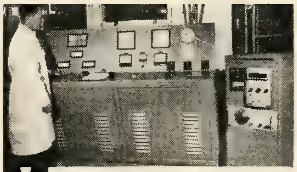
The quest for better propellants is now better termed a search for better propulsion. The coordination necessary for uprating tactical armament carries over into the research and technology aspects of the defense establishment.

The job in propulsion is tying the research to use—indiscriminate research in propellants has not paid off. The effort now is directed at finding more correlations between propulsion and weapons design. The net result is more latitude in propulsion—and a better performance level in the actual end-product.

A great deal of realism is going into the research and development elements funded by DOD—especially in satisfying the demands of conventional tactical combat. ■

PERMANENTLY
CALIBRATED BALANCER:
NO RESTRICTION
ON HEIGHT
OR DIAMETER.





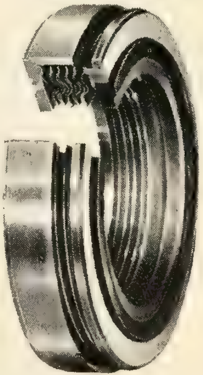
MB/Trebel equipment is the heart of the most modern space vehicle balancing facility in the free world.* Here, dynamic balancing makes it possible to improve accuracy, increase range, eliminate in-flight destruction of spin-stabilized vehicles due to severe coning angles. Newest in the MB/Trebel line of vertical, two-plane dynamic balancers is the FVD 1000 aerospace balancing system with remote control. It has a capacity of 7,000 pounds without limitations on diameter or height. Permanently calibrated for any speed from 50 to 1,000 rpm, it does not require trial runs or trial weights for calibration. **details on request*

LEADER IN VERTICAL & HORIZONTAL DYNAMIC BALANCING MB TREBEL
WRITE: MB/TREBEL. A SUBSIDIARY OF MB ELECTRONICS, 781 WHALLEY AVENUE, NEW HAVEN, CONN. 06508

Circle No. 13 on Subscriber Service Card

BELLOWS
SEALS
?

Call
on
Koppers



. . . but don't ask for a catalog. We haven't got one. Our metallic bellows-type face seals are all "specials." If you involve us in your problem you'll get the right answer faster than you could file a catalog. We do it with a sound, analytical approach, plus experience, and all the latest plant and lab facilities. We're not adverse to suggesting creative solutions, either (ever see a "gas face" like that big one up there?).

In short, we know when to use bellows seals and when not to—and why. If bellows seals are not your answer, we can make the right seal for you. Of course, the bellows is all metal, with no elastometric secondary seal elements. If what you want is improved sealing under difficult conditions of temperature, pressure, vibration or speed, then you'll want us to submit a design. Call on Koppers Company, Inc., Piston Ring and Seal Dept., 6503 Scott St., Baltimore, Maryland 21203, SA 7-2500, Area Code 301.

KOPPERS ®

SHAFT SEALS

Engineered Products Sold with Service

Circle No. 12 on Subscriber Service Card

Systems Planners Stress Modularity

Experience gained in developing strategic C&C capabilities should ease some problems associated with tactical hardware

LESSONS LEARNED in ten years of developing large and complex command and control (C&C) systems for strategic purposes will make it possible for the Dept. of Defense and the services to proceed more smoothly on the tactical level.

While continuing to improve its strategic systems, DOD has shifted its emphasis noticeably to the tactical areas (M/R, Dec. 7, p. 18), thus creating new requirements, new problems and new opportunities. Some strategic C&C concepts—notably in the "software" category—can be applied on the tactical level. But design of the actual hardware, both ground and airborne, will involve an almost completely different set of specifications.

The cry in the tactical regime is "modularity"—the ability to break equipment down or add to it so as to bring just the right amount of hardware to bear on a specific mission. The same word has also become basic to advanced strategic systems.

Pentagon sources say the day has passed for very large new systems, wherein designs are frozen early and massive funding is applied, with sometimes a 5-7 year wait before the equipment becomes operational (M/R, Dec. 3, 1962, p. 16). Emphasis now is on making better use of existing equipment, tying independently developed systems together, and adding on in a modular fashion (M/R, March 30, 1964, p. 79).

In the tactical area, therefore, a realistic assessment of what elaborate C&C systems can do will be made much earlier in the game than was the case with the larger systems. At the same time, C&C systems, as such, will become more difficult to define and harder to identify with a particular grouping of black boxes.

- **The market**—Initiation of new programs is expected to be rather austere, and projects are not likely to come forth as neat program packages. DOD planners do not, however, equate this with a decrease in the C&C market. In fact, they say the market for tactical C&C hardware actually will contribute more stability to the industry. They point out that the market is apt to show a steadily climbing curve, thus erasing the peaks and valleys associated with larger program packages and making market planning more realistic.

Several key programs already under way show promise of greatly increasing the military's ability to use advanced sensors and automated data processing (ADP) systems at the tactical level. These include the Navy's Tactical Data System (NTDS), the Marine portion of NTDS (MTDS), the airborne phase (ATDS), and the Air Force's 407L, 412L and 492L programs. There are other C&C programs linked to the ASW effort (Project A-New) and to the problem of providing airborne early warning and control (AWACS). Further in the future but potentially enormous development efforts are the Army's CCIS-70 program and the advanced Navy and Marine systems, ANTACCS and MTACCS.

Though the services are reluctant about disclosing total program costs relating to individual systems, the tactical C&C market should not be underestimated. The combined cost of the programs currently under way—including NTDS, MTDS, ATDS, 407L, 412L, and 492L—from inception through complete procurement (only one of these is even partially operational) is estimated at well over $2 billion. Depending upon the manner in which the Army's CCIS-70 program develops (it is now in a critical review period) and the advanced Navy and Marine systems, this very large market could be maintained well into the 1970's.

- **Development factors**—While ADP capability on the tactical level is obviously desirable, several factors have delayed its development.

One is the fact that the men who generally do the thinking about C&C have been almost exclusively concerned about the more urgent strategic role.

Another is the circumstance that, until the advent of microminiaturization techniques beyond the transistor, there was little practical possibility of moving ADP equipment into the field.

Now, however, the move has become practical. At the same time, there is a greater political-military interest in tactical warfare and controlling the way it escalates, in nuclear weapons and widely dispersed single-operator conventional weapons (such as *Redeye* missiles), and in the use of troops based in the United States.

There are still problems. The entire logic of tactical C&C must still be defined (there is still not a complete understanding of information sorting at the strategic level). Several combat exercises, such as the ones now being engaged in by the U.S. Strike Command, are leading to development of proper information theories in this area, but optimum commander-machine interfaces and language have yet to be developed.

A major goal of DOD policy is the interfacing of various service-developed tactical C&C systems so as to allow either common-language computer-to-computer communication or easily translated individual formats. Planners hope to achieve this economically and without taking away any user requirements.

- **Hardware needed**—Small and lightweight general-purpose digital computers using integrated circuitry are beginning to proliferate.

However, while computer progress has been substantial, the real hardware stumbling block appears to be in the peripheral equipments—in particular, displays.

Mobility, modularity, survivability, and economy are words used across-the-board by all services with a tactical mission when referring to C&C equipments. They are seeking improvements to communications gear of all varieties used in C&C situations—HF, microwave, hard wire, troposcatter—in all areas. Digital communications, in particular, will be expanded.

Part of the communications problem resides with management, which must insure that tactical C&C nets will not collapse in the event that a particular facility is lost. In this connection, there is need for more common usage and less special-purpose equipment.

Elsewhere in the communications area, DOD is now studying use of military comsats for C&C purposes. The study will detail who should use comsats, under what circumstances they should be employed, and the types of new ground and airborne terminal equipment that will be required.

Among the new sensors needed are lighter-weight one-man personnel- and vehicle-detection radars and higher-power, lighter-weight power supplies to operate them. Also, DDR&E officials are interested in more easily transportable 3-D radars and so-called gap-fillers to augment a radar network. And they want new techniques for netting radar patterns quickly.

Army, Marine and Air Force units with ground operations are all on the lookout for a solution to the radar line-of-sight (LOS) limitation now imposed upon ground-based surveillance. Several solutions are being studied, among them development of an over-the-horizon radar mobile enough to be applicable to a tactical situation, small enough so as not to make an easy target, and providing sufficiently accurate positioning data on targets.

Defense against low-flying aircraft continues to present a problem. As it has for decades, use of airborne radars operating overland or near the shoreline has been a potential solution. Despite large amounts of funds poured into development, however, there still is an acknowledged gap in being able to successfully perform this task well enough to pick out a moving target from a background of radar land clutter or extensive sea return.

- **DDR&E's role**—The Directorate of Defense Research & Engineering (DDR&E), responsible for translating C&C requirements into technically workable systems for the Joint Chiefs of Staff, is very much concerned with keeping the individual services' weapons systems loops clear.

DDR&E planners are attempting to define the interface at this level between incoming data and to establish a basis for deciding what information goes up the line to higher echelons or laterally to other service systems—and in what compatible format. They want to do all this in an optimum time frame, so as not to negate the effectiveness of particular weapons.

To insure that the knowledge gained in C&C development thus far is properly used, DOD has just set in motion an across-the-board functional review of defense command, control, and communications. The study will include over 100 major program elements and involve some 40 representatives from all Pentagon offices concerned.

The study is expected to be completed by mid-June, but the review group may become a permanent fixture.

The critical difference between this review and past, less formal forays into C&C is that all offices concerned with C&C in one form or another now will be brought together to work out joint requirements and problems. DDR&E will be able to look at a system through the eyes of persons able to accurately picture the forces the system will support, the manpower required to use it, the cost, installation and logistics problems.

Officials stress that the review group is not a requirements-forming body but is basically intended to review systems now under development, or proposed new systems, on a five-year basis.

A run-down on the current and future tactical C&C programs follows:

- **Naval Tactical Data Systems (NTDS)**—NTDS is the largest part of the three integrated Navy and Marine Corps tactical data systems under development, and the only one among all of the semi-automated tactical systems being pursued by the services that is tagged as operational.

Six ships in the Fleet are now equipped with NTDS, including two nuclear vessels — the attack carrier (CVA) USS Enterprise and the guided missile cruiser (CG) USS Long Beach. Several other guided missile frigates (DLG's) are also now nearing completion. The carrier USS Kitty Hawk is receiving equipment during retro-fit and the new attack carrier USS America will receive NTDS as original equipment.

Current plans call for all major U.S. warships (CVA's, CG's, CLG's, and DLG's) to be fitted with the equipment, with the installations completed in the 1969-70 period. This probably would involve 13-14 attack carriers, 30-35 frigates, and about 10 cruisers. While NTDS is not scheduled to go aboard destroyer-class vessels, there is some discussion within the Navy as to the possibility of putting it aboard smaller vessels in the future. Certain AGC command ships also are expected to be equipped with a version of the system.

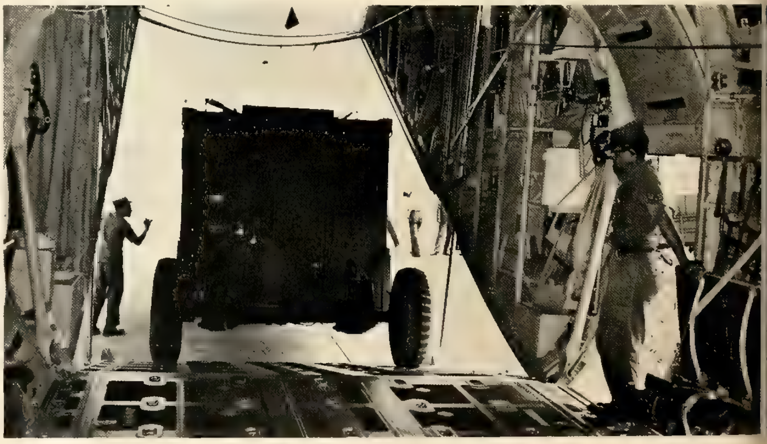
The cost of development and procurement of NTDS equipment to date, including the $21.6 million requested for FY '66, is about $300 million. Based upon current plans, the additional cost to complete the program is approximately $125 million.

In its initial role, NTDS is concerned primarily with fleet air defense, but its use in training exercises is now being expanded into other fleet functions involving integrated surface operations, navigation, air traffic control and electronic warfare.

NTDS replaces the traditionally manual functions of a shipboard Combat Information Center, making possible a variety of computer-aided decisions regarding target identification, threat evalution, recommended course of action, and weapons system selection.

NTDS includes beyond-LOS computer-to-computer automatic HF digital data communications links which tie together inputs from radar, sonar, and ECM sensors aboard all NTDS ships (and aircraft), presenting a real-time situation report on all ships' displays. The Navy says targets detected by a screening vessel, for example, are automatically transmitted and displayed on other ships' consoles, with provision for target sorting to avoid duplication. Collins Radio Co. is communications prime.

The existing NTDS network is basically a surface operation, with airborne data link, but does not now include a direct tie-in with submarines. Future expansion of the system from air defense into amphibious operations, ECM, and ASW missions will be accomplished primarily via software modi-



fications to NTDS computers.

NTDS equipment includes up to four Univac USQ-20 stored-program general-purpose digital computers aboard each ship. CVA's carry four, DLG's carry two.

Each ship also carries between four and 25 displays. This portion was developed by Hughes, but now includes a heavy involvement by the Hazeltine Corp. Direct-view CRT's are used both for on-line digital information from the computers and for radar-derived data.

In the computer area, the Navy is seeking to make improvements in speed and storage capability without changing computers. The major problem is the loss of individual computer core availability, when additional computers are added to existing ones, due to the necessary inter-computer data exchange requirements.

In recent deployments, Navy task force commanders report, the Enterprise and Long Beach were exercised using NTDS in the air defense role, with aircraft raids far exceeding numbers normally used. They say these ships never reached a saturation point in their ability to handle such raids, while conventional CIC's were saturated.

Navy planners stress that NTDS planning is now closely linked with future ship-board weapons systems, just as in earlier periods the system had to be compatible with existing systems. NTDS basically stops at the weapon control system, having supplied it with the needed target data. The means by which the NTDS interfaces with new weapons could reflect format changes which would allow direct digital data input to those weapons, for example, rather than requiring a re-conversion to analog form. Such a procedure could be followed with the *ASMS* program. The 3-T (*Terrier-Tartar-Talos*) missile improvement program also involves increased integration with NTDS.

- **Airborne Tactical Data System (ATDS)**—The airborne portion of NTDS, carried aboard the E2A aircraft, represents an attempt by the Navy to provide much more than traditional airborne early warning for the fleet. The E2A will carry extensive on-board data-processing display and evaluation gear, and the required digital and voice data links to tie into the surface NTDS with the same basic capabilities.

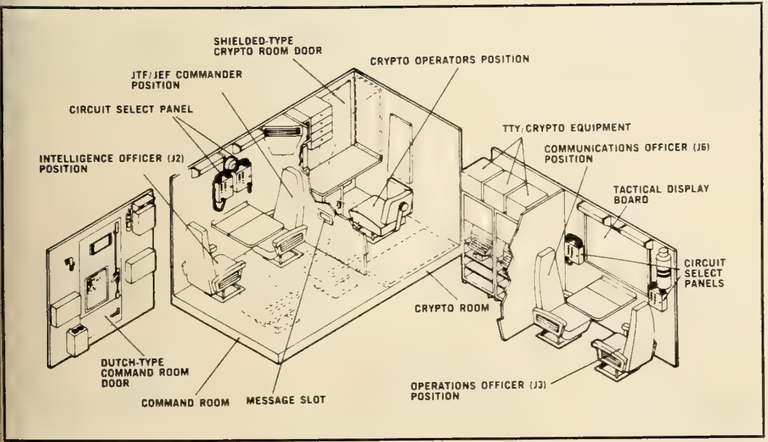
Though the program has been beset with technical problems which have caused a stretch-out in procurement, Navy project directors told M/R they feel that the ATDS/E2A will be operational this year.

The ATDS primary equipment includes the huge 20-ft.-dia. GE APS-96 UHF radar, and two Litton computers for detection and automatic target tracking used in intercept or control. Troubles with the ATDS system to date have been primarily in the avionics, but they have not been all technical. The training program for service operators has been elaborate, and much effort is aimed at improving service operator efficiencies with equipment far more complex than its predecessor.

Cost of developing and procuring the ATDS/E2A to date is about $1 billion. Substantial buys still are programmed beyond FY '66.

The Navy has had a long-term interest in developing an overland version of the E2A, for better fleet AEW. However, while the aircraft, operating in its current role over water, has improved clutter-rejection circuitry to reduce target-hiding sea return, the problem of developing a radar which can pick out moving targets over a land mass background has still not been solved to the Navy's satisfaction. "The technology frankly has not come forward on overland radar," says one officer.

OPPOSITE PAGE: Transportable shelter for 492L JACKPOT system is off-loaded from C-130E transport. BELOW: Schematic of STRICOM's 492L JACKPOT C&C equipment.


SHIELDED-TYPE CRYPTO ROOM DOOR
CRYPTO OPERATORS POSITION
JTF/JEF COMMANDER POSITION
CIRCUIT SELECT PANEL
TTY/CRYPTO EQUIPMENT
COMMUNICATIONS OFFICER (J6) POSITION
INTELLIGENCE OFFICER (J2) POSITION
TACTICAL DISPLAY BOARD
CIRCUIT SELECT PANELS
CRYPTO ROOM
DUTCH-TYPE COMMAND ROOM DOOR
COMMAND ROOM
MESSAGE SLOT
OPERATIONS OFFICER (J3) POSITION

- **AWACS**—The Air Force is pursuing a similar project as an adjunct to command of tactical air forces under the AWACS experimental program. Though both the overland E2A project and AWACS are at least expected to flight-test various proposed solutions to the problem, the tone of the recent DOD posture statement on the problem is urgent but not optimistic. Secretary McNamara, in reducing the AWACS effort to a $3-million level for FY '66, says that "the attainment of the hoped for performance is very unlikely."

Several firms are working on solutions, some using company funds, and some would no doubt disagree with the Secretary's statement. However, McNamara also said the capability was so important that an additional $8 million would be included in the budget to explore the terrain clutter-rejection problem as an advanced technology effort.

The Marine Corps is also highly interested in an overland E2A.

- **A-New**—Within the Navy's combat-direction type of C&C development is another airborne system, Project A-New, which has registered significant progress in recent months and whose heretofore low-budget operation may belie its long-term potential as a major market for C&C system suppliers.

A-New, briefly, is a Navy ASW management experiment to tie together improved undersea sensors with on-board data-processing and display systems, and also with basic aircraft improvements such as more precise navigation procedures. The objective is a fully integrated airborne ASW system.

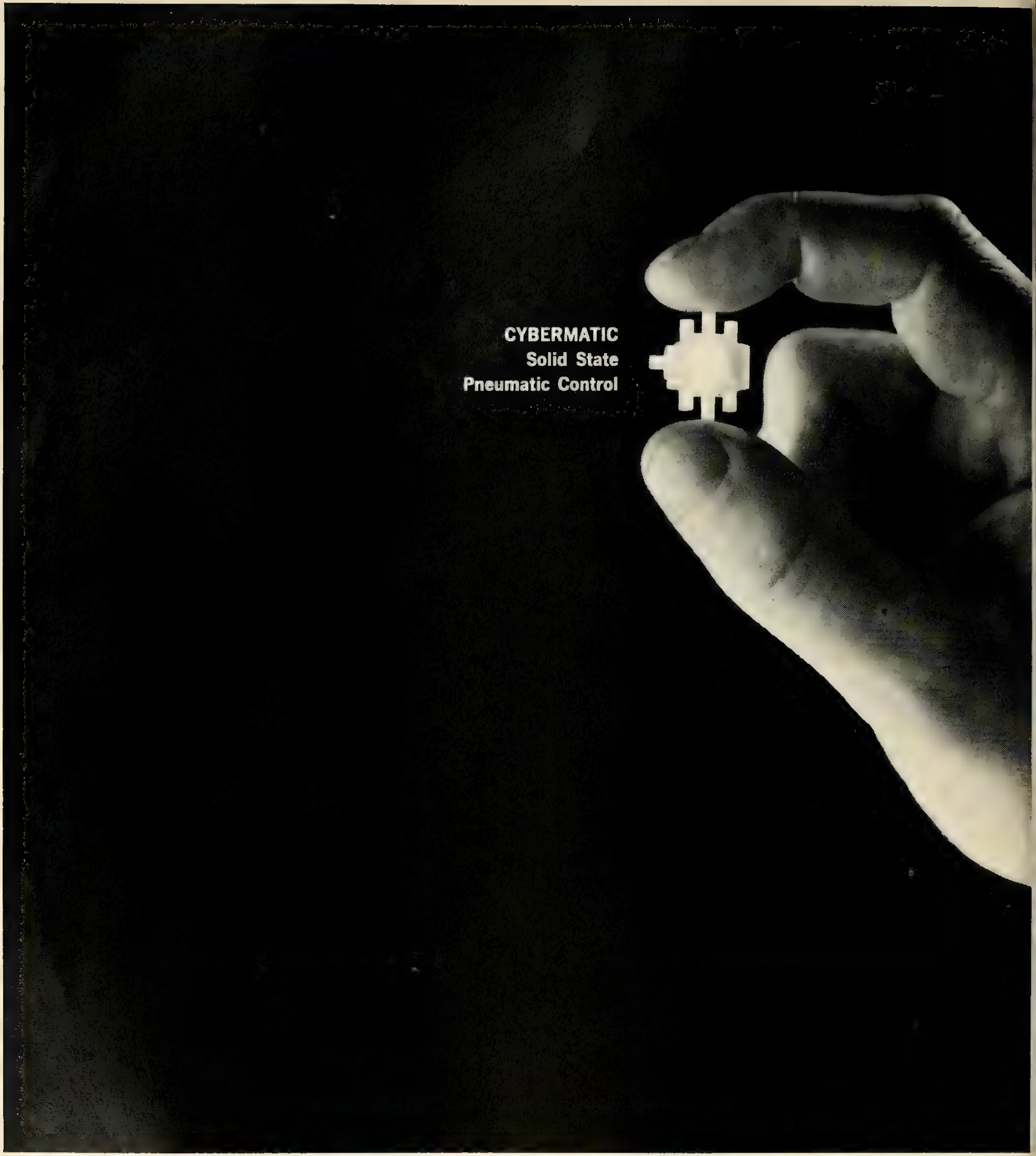
A-New has progressed very rapidly, both in the laboratory and in flight tests, especially in the signal processing area.

Navy recently reported major gains through addition of a modified *Titan II* digital computer to the system.

In other ASW-related C&C projects, the DOD, in its FY '66 request, asked for $1 million to investigate the feasibility of developing an ASW/Ship Integrated Combat System which would integrate command and control with the control of weapons and sonars. DOD feels that such a system would be "particularly useful in an ASW escort ship, where a quick coordinated effort is essential."

- **Marine Tactical Data System (MTDS)**—This system ranks as the purest tactical semi-automatic C&C under development—in that all ground environment problems are present.

MTDS has been under development since the mid-50's, and to date has cost an estimated $140 million, about 70% of which is related to data processing. Delivery of first equipments to the Fleet Marine Force is expected in July, with subsequent tests and an expected opera-



A MAJOR TECHNOLOGICAL BREAKTHROUGH BY JOHNSON

This "impact modulator" is the pneumatic equivalent of the transistor. What the transistor did for electronics, Johnson now makes possible in pneumatic control. The new Cybermatic concept is the result of Johnson's pioneering role in the field of pure fluid devices.

JOHNSON SERVICE COMPANY / MILWAUKEE, WIS. 53201 / 110 DIRECT BRANCH OFFICES

JOHNSON CONTROL
AUTOMATIC CONTROL SYSTEMS

Circle No. 11 on Subscriber Service Card

tional date in 1966, although that date could be pushed up. All equipment is helicopter-transportable.

There is still substantial procurement ahead, probably continuing into 1969-70. NTDS, now primarily concerned with anti-air warfare and control of direct air support of front-line troops, is also expected to expand into air traffic control and air support center utilization in the future. Current plans call for equipping all nine Marine Air Control Squadrons, three Tactical Air Command Centers (one for each wing), and a Reserve Wing.

While MTDS makes use of much existing hardware, it has also spurred development of new sensors, displays, and weapons control devices. The basic intent of the system is to provide the Marines—through use of an integrated radar network, ADP, and a two-way data link with interceptor and support aircraft—with a means in which to handle more target tracks and intercepts than heretofore possible.

The system makes use of the same Univac computer utilized in NTDS, using it also for the interface with that system and with ATDS.

The system will use three basic radars, including a Sperry-built TPS-34 3-D search radar which reportedly boasts advanced ECCM capabilities and new IFF data processors—an area that is very much a problem with high-performance aircraft operating on low-level support missions.

The original AF/Westinghouse TPS-22 early warning radar used in the development program probably will be replaced in an operational role by a new system developed by ITT-Gilfillan. The light-weight two-dimensional gap-filler radar used is the RCA UPS-1.

The system now uses a series of 19-in. CRT displays and an iconorama type of non-real-time presentation. The Corps is intensely interested in new deployable 6 x 6-ft. projected real-time displays which are being pursued by some firms. There is also major interest in new 3-D type of displays, and in a solution to the LOS radar problem.

• **ANTACCS & MTACCS**—Studies of major importance to the tactical C&C area from 1970 to 1985 are being undertaken through the Office of Naval Research to determine the needs for advanced Navy and Marine Corp systems.

The Navy portion, ANTACCS, is being studied under contract to Booz, Allen, Inc. and Informatics, Inc. The studies were begun in January, and Phase I is now completed. Phase 2 contracts are expected to be let shortly; three awards probably will be let and two other firms may join Informatics for the follow-on.

The ANTACCS effort is basically a systems evaluation for the 1970-1980 time period. In addition to a complete industry-wide technical review to determine data-processing, display, and software capabilities, it calls for an assessment of the threat likely to exist in that period, a study of the problems of interfacing with other service equipments, and an examination of tying in more extensive Naval missions including ASW, ECM, intelligence, logistics, and administration. Basically, the intent is to help Navy planners come to a decision regarding a future system.

The major decision to be made is whether to integrate all of the tasks through a major new system or to interface with existing ones.

Early results of the studies reportedly point to a need for further development of large screen displays. Smaller devices are believed to be well in hand. Improvements in computer-to-computer communications and inefficiencies in adding on computer capacity, already noted in NTDS, also will need study. Increased use of integrated circuits and resultant computer diagnostic procedures are a certainty. Improvements in remote computer inquiry and operator programming techniques will be sought.

Analysis of a potential enemy threat will also have a major bearing on future C&C sensors, communications, and doctrine. ASW, electromagnetic warfare, sub-launched ballistic missiles, and satellite surveillance of the fleet all will affect systems design. For example, one scientist points out that satellite surveillance of the fleet would possibly allow a relaxation of certain radio silence measures, while causing a re-thinking of fleet deployments vis-à-vis the location of enemy ICBM bases.

There is little doubt that passive EMW type of sensors will contribute increasingly to C&C systems.

Marine planning is being carried out by the Naval Warfare Research Center at Stanford Research Institute and also by Informatics. The MTACCS system is viewed as becoming available in the 1975-85 period, mainly because the system is somewhat behind NTDS in terms of deployment. The Marine system envisioned involves a completely integrated ground-and-air C&C system able to coordinate all elements of an amphibious assault and project them ashore by means of data link.

• **Army-CCIS-70**—The Army's large-scale program to bring automated capability to the field commander may soon move towards actual development.

Army officers told M/R they are hopeful that this will be the year for CCIS-70. A detailed master plan and implementation program for the project, something which has been lacking in the past, has been submitted to the Dept. of the Army by the CCIS-70 project office and the Army's Combat Developments Command, which develops the user requirements. Army approval or modification of this plan was expected to be handed down this week.

With approval, officers say that the Army can then proceed on a coordinated and concentrated effort toward development of a first-generation CCIS-70 system. Officers are also expected to hold an industry briefing on the program, if approved by the Army and DOD, this year. There is a large new business potential.

The CCIS-70 project through FY '64 has received in excess of $16 million in funding, although some of this remained as unobligated funds carried into FY '65. For FY '66, McNamara has asked for $13 million more.

The program is divided into five interrelated Army functions: fire control, intelligence, operations, logistics, and personnel. The first system to be fielded will be the fire support, since that is highly desirable in terms of fighting a tactical nuclear war in Europe. The next system will be either intelligence or a combined operations-intelligence operation. The $13 million for the coming fiscal year is to apply to getting detailed studies started in the other areas, which have not received as much attention to date.

Several projects now under way are laying the groundwork for eventual CCIS-70 development.

A test bed has been set-up at Ft. Huachuca, Ariz., for systems analysis using already developed Army equipments.

Use of the Army Tactical Operations Center (ARTOC), the MSQ-19 system, as a feasibility mode to test automation of staff procedures within a headquarters, was carried out under Exercise Major Domo.

In the U.S. Seventh Army in Europe, a CCIS-70 team has made detailed studies of the existing capabilities to handle digital communications. Although it reports some encouragement regarding some aspects of existing communications, the Army says this is an area where a new development effort may be called for. In particular, it would like to bring in systems which would more closely match the bit rates of computers. One solution may be introduction of PCM equipment.

Also in the Seventh Army, demonstration teams are using the FADAC M18 gun direction computer to automate computation of firing data. They report excellent results. CCIS-70 probably will require a new lightweight computer, possibly one which can be bought off-the-shelf, but the FADAC is expected to serve either as a building block for that computer or as an interim device.

FADAC will be distributed to all

Army divisions and possibly to several other countries, and distribution probably will be completed in FY '66.

Also at Ft. Huachuca, competition for an important CDC CCIS-70 integration study, to be awarded imminently, has reportedly been narrowed from 16 firms to four. The study will view all integration considerations of the project's functional systems through data-sharing and other techniques.

There is considerable foreign interest in CCIS-70. The French have already contacted the Army to determine the degree of compatibility available. The Germans reportedly have expressed an interest in actually participating in system development.

The Army, like the other services, is not overly concerned about the capabilities of data processors; like everyone else, it is concerned about displays.

The effect of ADP upon nuclear fire control and target analysis should be enormous. Rather than have a spotter check the position of successive rounds of ammunition, highly improbable with nuclear weapons, a computer, in an iterative process taking only fractions of a second, can actually solve the ballistic equations associated with firing a projectile from one point to another, thereby bringing first rounds right onto a target, coordinating the fire from several batteries, and maintaining the element of surprise.

This should greatly reduce the time it normally takes to plan coordinated firings. ADP will also allow cranking in last-minute weather and wind data prior to nuclear weapons use.

In addition, Army officers point out that from an intelligence standpoint, data storage at hand and rapidly accessible will allow sensor data on targets to be checked against stored signature files, and against a "no-fire list" that could be programmed in by operators.

- **AF Tactical Air Control System (407L)**—Development of a highly mobile electronic communications and control system that can deploy with squadrons quickly and to any locale continues to be a major, if somewhat elusive Air Force goal. The TACS system is now reported to be in an equipment acquisition phase on an "urgent basis."

Early equipment used in the program will be mobile, but will require more airlift capability than the Air Force wants to use. Early systems will be manual, with air controllers using sensor outputs and command links to vector IAC aircraft. Eventually, the Air Force expects to phase in ADP equipment, but the requirement now is to get usable equipment into the field to perform the mission.

407L will include a mix of radars, some of the heavy variety and some of the so-called gap fillers, off-the-shelf communications equipment, and helicopter-transportable control centers.

Beyond the equipments now being procured, a major effort is being made to field an improved TACS in the future. AF planners are looking towards field-type data-processing, light-weight 3-D radars, portable troposcatter sets for beyond-LOS communications, and major gains in virtually all areas associated with mobile tactical equipment—including housekeeping and life support equipment, power generators and helihut control centers.

AF has asked for cost proposals from four firms for possible procurement of light TPS-44 L-band surveillance radars in connection with 407L.

The total program for TACS is believed to be worth about $250 million.

There is also major interest in the equipment being developed and now put into service by the Marine Corps, just as the Marines initially used some AF-developed radars to get their system into the field. Marine data-processing gear and field radars may wind up in AF inventories. There has also been some Congressional inquiry into the ability of the Air Force to use this gear.

The service is also pushing hard in the two most pressing radar problems—overland and long-range ground-based systems.

It is also now considering use of comsat relay for some TACS data.

- **Air Weapons Control System (412L)**—AF and DOD planners now are reportedly working out details of setting up a 412L-type of fixed-base overseas tactical air defense system in the Pacific, M/R has learned. The decision to make such a move already has been made, according to informed sources. It could be placed in the Hawaiian Islands, and in the Ryukyus.

The basic 412L system in West Germany was turned over by Air Force Systems Command for operational use by USAFE earlier this year. 412L, which has some mobile elements but is primarily a fixed-base system, consists of a computer-equipped hardened combat reporting center and at least six other hardened or underground sites stretching for hundreds of miles near the East-West German border. The system costs $300 million.

- **USSTRICOM C&C System 492L**—The Strike Command was formed in 1961 and is the newest of the joint or unified commands, composed of elements from all services. It is supported both at its headquarters at MacDill AFB, Fla., enroute to the objective area, and in the field, by 492L.

Though the basic concepts and major elements of 492L are at least identified, 492L is in the operational analysis and design stage. Data Dynamics, Inc., a California-based firm, is doing the ops/anal work under Electronic Systems Div. contract. The firm's study, which began last August, will be completed in August 1965, and probably will signal commencement of some early hardware acquisition. Project officers speculate that some equipment procurement may be initiated in late FY '66, probably for headquarters gear, with the larger buys coming in subsequent years. ESD will be the contracting agency.

Though still being evolved, 492L does have some functioning equipment, including available computer facilities at MacDill and initial communications equipment used for airborne and ground operations. Availability of this equipment early in the development is providing STRICOM with an ability to develop more refined requirements for the operational system.

The three major 492L elements are the Joint Operations Center at MacDill, which will be permanent headquarters for CINCSTRIKE, and will include computers and automated displays; the Joint Airborne Communications Center/Command Post, commonly referred to as JACKPOT, which will provide communications for the Joint Task Force Commander in the air enroute to the objective area and then unload equipment suitable for rather austere field communications use; and the Joint Operations Center (Field), a more extensive system than JACKPOT, which will be brought in for extended ground-environment operations.

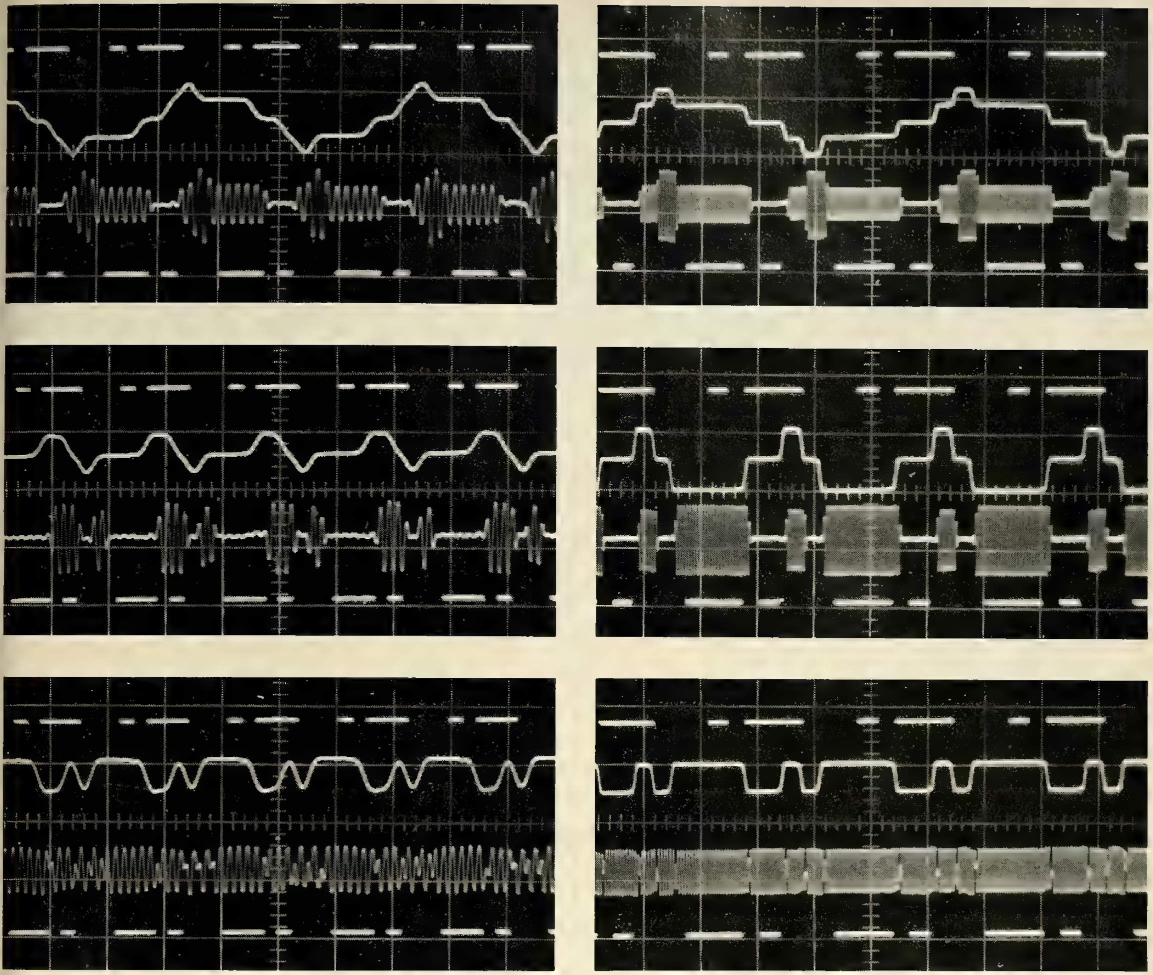
First JACKPOT system has already been delivered to STRICOM and has been used in tests last Spring in the United States and in Africa. Modifications resulting from those tests were designed into a second system delivered in August.

JACKPOT is being developed by the Westrex Communications Div. of Litton Industries under an ESD contract. Westrex reportedly delivered the first system 54 days after the contract was signed.

JACKPOT is described as an austere system by the Air Force, but one which would meet the initial needs of the JTF for the first 96-120 hours of deployment. It is, however, likely to become a part of an operational 492L system.

JACKPOT consists of two S-141 shelters, one housing the command gear and the other the communications equipment. Both are mounted on transporters and can be carried together in a single C-130E Hercules transport.

The C-130E is also equipped with special antennas so that the JACKPOT equipment can be used for C&C en route by the JTF, and then rolled out of the transport, towed away, and set up for field use. Once on the ground, the system can be operational in two hours. ■



MOST OF OUR SPACE ACCOMPLISHMENTS ARE A LOT OF TALK.

For example, the above is a typical readout of one of our data links.

Whether voice or data link, in space or from the earth, space communications is our business. We have the in-house capability to run your next space communications system from feasibility study, through design, manufacture, final installation, checkout and operation.

We designed and built the first fixed, mobile, shipboard, and airborne stations for communications using a synchronous satellite. Recent tests run in cooperation with the Air Transport Association and Pan American Airways proved the feasibility of solid transocean communications with operational jet aircraft via the NASA Syncom III satellite.

Our space talk began at the dawn of the space age with the worldwide Minitrack network and grew up with the Mercury, Advent, Syncom, and Gemini systems. We are feeling the pulse of the future through studies on MORL, OSSS, ALSS, LORL, MOL, and Voyager.

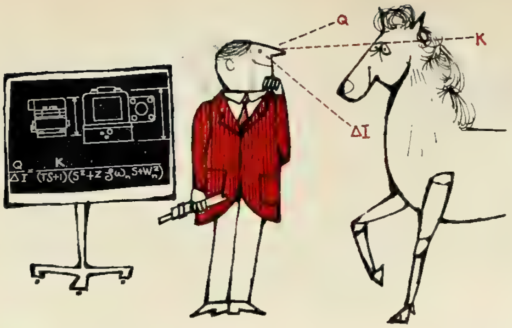
In the hard world of space hardware, we are currently building equipment for a rocket program. We have recently developed an advanced 5-watt solid state S-band transmitter and a low noise receiver. We are in the process of developing a new generation of ultra-reliable wideband data link aerospace communications systems with a mean time between failure goal of 10 to 20 years.

In addition, we are developing an electronic camera with a sensitivity and response time markedly beyond the scope of present space sensors.

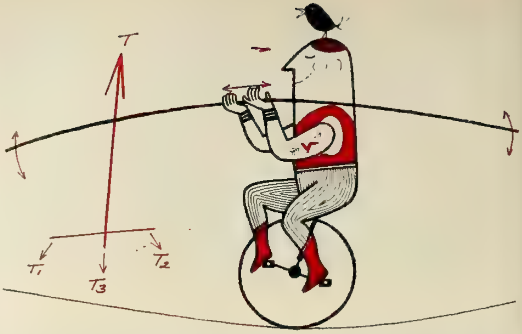
If what we've been talking about is in line with your next space project, contact us at Bendix Radio Division, Baltimore, Maryland 21204. Perhaps we can talk something up.

Bendix Radio Division THE Bendix CORPORATION

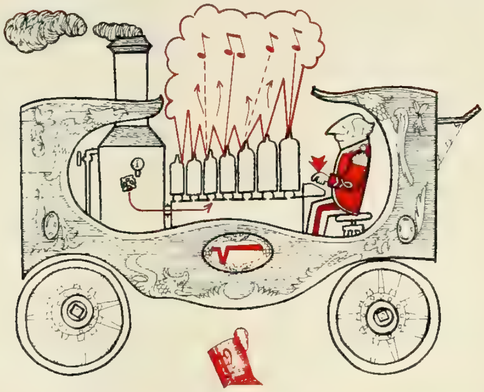
Circle No. 10 on Subscriber Service Card



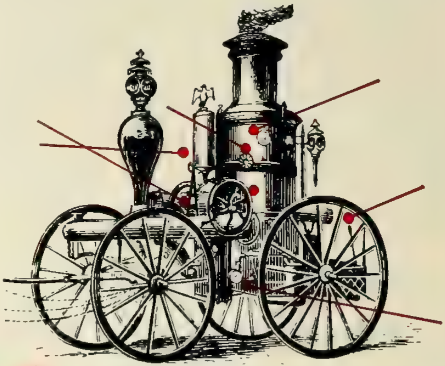
HOW TO PICK A WINNER! **SERVOVALVES** OR HORSES



WHAT DOES A PUMP MAKER KNOW ABOUT ATTITUDE CONTROL?



EXPERIENCE MAKES THE DIFFERENCE IN HI-TEMP CONTROL



FORERUNNER OF REACTION CONTROLS?

THE PUMP MAKER AND THE HATS

What about the pump maker and his many hats? They may appear quite a bit different at first glance, but all perform a similar function.

These "hats" merely cover the various facets of Vickers special appeal—mastery of the science of fluid dynamics. They've been worn with assurance and aplomb for more than 40 years . . . the various aerospace specialties depicted are a logical extension of the basic science.

Servovalves—If that's your interest then let Vickers show you how to pick a winner by the proper balance between performance and cost. Both jet pipe and flapper nozzle designs are available too.

Reaction Controls—Experience dates back nearly 10 years—translates into assured performance on your "bird" wherever it flies.

High Temperature Pneumatic Controls—Hard work and lots of experience with solid and liquid propellants make Vickers a virtuoso on the tough jobs. Actuation, porting and controlling volume of flow are part of today's capability.

Got an Aerospace Fluid Dynamics Problem?—Let us help with the solution. To learn more about our qualifications write for Data Folder PM-1001 to Vickers Incorporated, P.O. Box 302, Troy, Michigan.

2176

VICKERS

DIVISION OF SPERRY RAND CORPORATION

Circle No. 9 on Subscriber Service Card

Big Emphasis Is on Airlift, Sealift

Continuing attention to vertical envelopment capability to boost helicopter buys; amphibious, ground troop mobility enhanced

FAST DEPLOYMENT of ground forces over long distances—often from within the continental United States—will advance to the point where this nation's 30-day airlift capability alone will be five times greater by the end of Fiscal Year 1970 than it was at the end of FY '61.

Sealift capabilities will also be greatly enhanced over the FY '66 to FY '70 program period. Two of the most dramatic developments in long-range mobility, the C-5A transport and fast-deployment logistic ships (roll-on/roll-off types), will take long strides forward in the FY '66 budget request of $1.6 billion for airlift and sealift forces. That total is $100 million more than the FY '65 estimate and $700 million greater than the original FY '62 request.

Introduction of the C-5A, plus completion of procurement of the Lockheed C-141, should go a long way toward improving U.S. airlift capabilities, Defense officials say. The C-5A will allow "integral airlift," in which the personnel associated with heavy equipment—the infantry carried by armored personnel carriers, drivers of 2½-ton trucks, for example—would sometimes travel in the same plane with their vehicles.

Similarly, the forward mobile depot ships will provide an "integral sealift," in that they can be used like piggy-back trailers on railroad flat cars. They will carry heavy equipment in controlled-environment holds, meet with troops flown in from rear areas and will be able to travel with the fleet because of their fast (25-knot) speed.

Defense Secretary Robert S. McNamara also foresees these fast logistic ships being dispatched from the continental U.S. to distant threatened areas, carrying, without disassembly, heavy tracked and wheeled vehicles as well as helicopters.

- **C-5A funding**—In the C-5A program, the Air Force hopes to move ahead to the tune of $157 million for initiation of development in FY '66. McNamara in his posture statement told the House Armed Services Committee that pacing items in the C-5A program are the engines and the required high-flotation landing gear.

He estimates the C-5A program's ultimate cost at $2.2 billion, including development and procurement of a "modest force of operational aircraft," plus 10 years of operation. The Boeing Co., Douglas Aircraft Co. and Lockheed Aircraft Corp. are competing for the airframe contract.

According to a spokesman for one of the airframe competitors, the C-5A will be designed to deliver payloads from 140,000 to 270,000 lbs. into forward area bare dirt fields 3,500 ft. long. Thus the need for high-thrust engines and the high-flotation landing gear. One DDR&E official emphasizes, however, that the plane would have to make repeated landings at the same sites so that some surface improvement and maintenance would be necessary.

It has been estimated by some that the plane, travelling at high subsonic speeds, could carry 600 airborne troops and between 700 and 750 in a passenger plane configuration. The C-5A weight quoted by McNamara is "in the 725,000-lb. class."

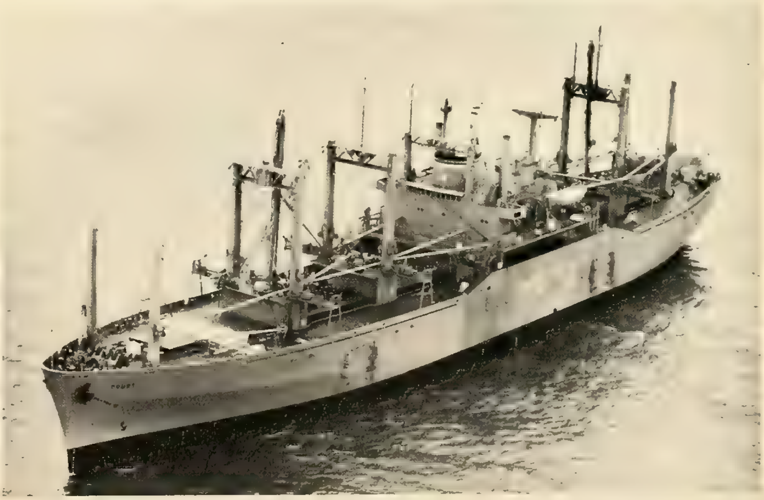
- **New marine engine**—McNamara cites as a "real advance in marine engineering" the powerplant envisioned for the fast-deployment logistic ships. It would be a marine version of an aircraft-type gas turbine engine coupled to an electric generator/motor. A bidders' conference has been held and requests for proposals on the powerplant are expected to go to industry soon.

The number of these ships to be built has not been given by Defense officials, but the FY '66 budget for sealift forces requests $131.8 million to begin construction of four all-new vessels. One of these would be powered by the new gas turbine engine.

The new class roll-on/roll-off fast-deployment types require only the most primitive dock facilities—facilities that can be quickly established by engineers.

A spokesman in the Office of Naval Material said the ultimate standard size roll-on/roll-off ship would be 550 ft. long and have a loaded displacement of 13,000 tons.

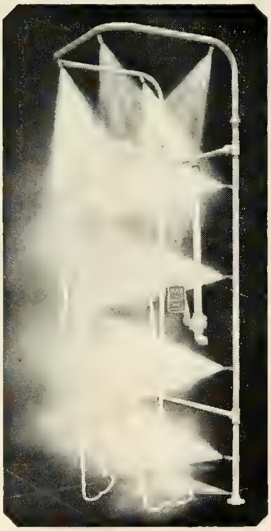
Defending the ships should not present problems since their speed will give them the fleet's protection.



COMET I, the first true roll-on/roll-off ship, which is already operational in the Philippines. It is a forerunner for a new class of fast-deployment logistic ships.

FIRST AID ON TAP

For the Flood of Relief

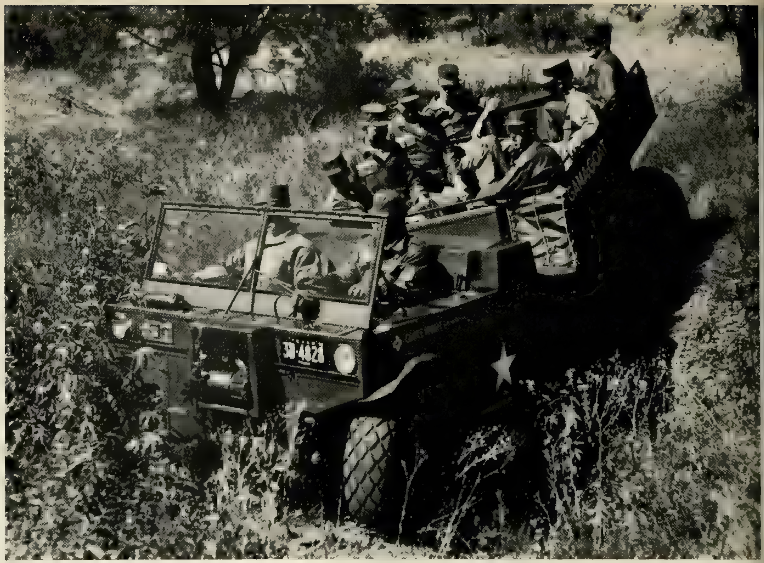


Instantly washes away harmful contaminants from the face and body! This Model 8590 Drench Shower is operated by Haws' instant-action ball valve for immediate "First Aid on Tap!" Insist on Haws today!

HAWS EMERGENCY DRENCH SHOWERS

HAWS DRINKING FAUCET CO.
1443 Fourth St. • Berkeley, Calif. 94710

Circle No. 8 on Subscriber Service Card



THE ARMY XM-561 articulated 1¼-ton cargo or troop truck, developed by Ling-Temco-Vought, Inc., which should enter the Army's vehicle inventory within a few years.

HELICOPTERS

More helicopters will be added to the military inventory than any other types of aircraft in the FY '66 through FY '70 program period, further increasing Army and Marine Corps tactical mobility.

One DDR&E official probably best expressed the consensus regarding the rotary wing vs. V/STOL argument by saying that helicopters still offer the "greatest advantages and widest applications in mobility" for some time to come in tactical situations like that encountered in South Viet Nam. This official held that the V/STOL aircraft envisioned as replacements for helicopters probably won't be able to nudge helicopters out of the picture until the distant future.

Another DDR&E spokesman points out, however, that the helicopter does not offer a very good means of high-speed transportation in longer tactical missions. He holds out hope for successful development of such V/STOL craft as the Ling-Temco-Vought/Ryan/Hiller XC-142A four-engine, 400-knot turboprop transport, the only V/STOL aircraft now committed to operational evaluation, for use on longer missions with vertical ascent/descent requirements.

- **Army purchases**—The Army has requested $344.5 million in FY '66 funds for procurement of 1,018 aircraft. The largest single item in the request covers funds for the Bell UH-ID general-utility helicopter being used so successfully in South Viet Nam for transporting troops and cargo.

The Army buy also includes $75.2 million for the Boeing-Vertol CH-47A transport helicopter (see cover).

- **Navy, Marine Corps procurement**—The Navy and Marine Corps proposed aircraft buy in FY '66 amounts to 659 and $1.545 billion. Of this total, the number of attack aircraft will decline, but the number of helicopters will continue to increase over the next few years, "reflecting our recent emphasis on the vertical envelopment capability," according to McNamara.

The most advanced rotary wing aircraft included in the FY '66 buy will be the Marine Corps Sikorsky-built CH-53A, a 38-man heavy assault helicopter. The craft is the first earmarked to receive the Integrated Helicopter Avionics System (IHAS), an electronics package that will permit all-weather, day and night operation.

Some slippage in the IHAS program has been indicated by spokesmen in the Office of Naval Material, enough that the first production models delivered probably will not be equipped with the system. A production CH-53A flew for the first time at the end of 1964.

A model mission envisioned for the IHAS-equipped CH-53A, say DDR&E officials, would be for it to navigate 150 miles inland after carrier takeoff and deliver troops to within one mile of their destination at speeds close to 200 mph. The craft would also have station-keeping equipment so that it could act as a "bird dog" for accompanying helicopter types, principally the 17-man CH-46A built by Boeing-Vertol.

- **Big lift helicopters**—Both Army and DDR&E officials agree that the

F&M Systems Company is responsible for detail design, fabrication, installation, and checkout of a highly advanced data acquisition and instrumentation system for the TITAN III-C Rocket Motor Test Facility at Edwards Air Force Base, California. The Air Force facility will be operated by United Technology Center for testing UTC's million-pound thrust, solid propellant motors, two of which will make up the first stage of the TITAN III-C.

HOW TO INTERROGATE A MILLION-POUND THRUST

At Edwards Air Force Base, for example, F&M Systems has furnished a data acquisition and instrumentation system providing 564 information channels and 121 channels of control. Strain gauges, thermocouples, and other transducers gather information on stress, pressure, temperature, vibration, etc. F&M instrumentation calibrates and conditions this information for data recording. Video and audio site communications, safety controls, "quick-look" oscillographic data displays, and go–no-go indicators are also included. This F&M Systems' project required over a quarter-million terminations.

F&M Systems Co. is a division of Fischbach and Moore, Incorporated, one of the largest electrical contracting firms in the world. F&M Systems accepts total responsibility — from design through on-site checkout — for instrumentation of electronic, electro-mechanical, hydraulic, pneumatic, and nuclear systems.

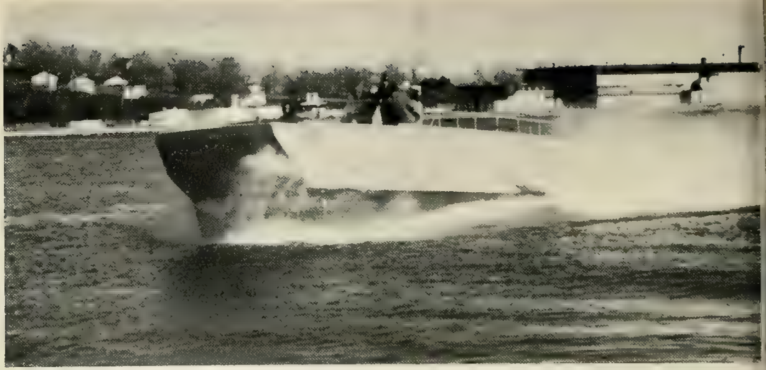
F&M SYSTEMS CO.

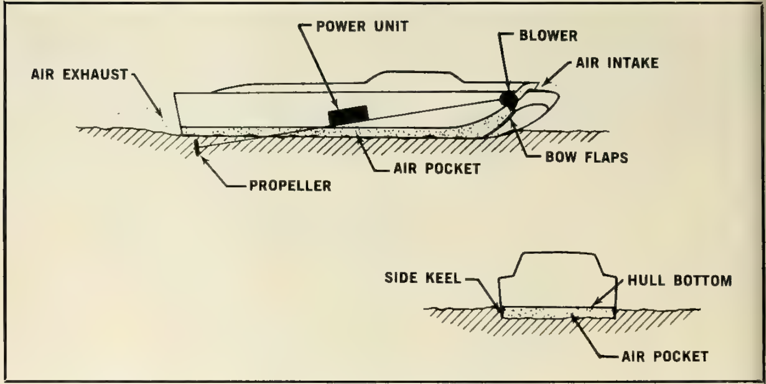
A DIVISION OF FISCHBACH AND MOORE, INCORPORATED

P.O. BOX 20778   AREA CODE 214, CH 1-2121   DALLAS, TEXAS 75220

Career opportunities for competent engineers . . . with an equal opportunity employer.

Circle No. 7 on Subscriber Service Card





NAVY VERSION of Hydrokeel landing force support vehicle undergoes testing in photo at top. Diagram illustrates the captured air bubble principle the Hydrokeel uses.

need exists to develop a heavy lift helicopter capability. Six Sikorsky CA-54A "Flying Crane" prototypes were bought in FY '63. They are undergoing operational evaluation to see if the heavy lift concept is feasible.

The Flying Crane now in advanced development can lift six tons over moderate ranges and has a maximum capacity of up to 10 tons. But Maj. Gen. William W. Lapsley, commander of the Army Mobility Command, said at DOD's Advanced Planning Briefings for industry earlier this month in Los Angeles that a requirement exists for heavy-lift aerial cranes in the 12- to 20-ton range.

Lapsley said that "design and development of such helicopters represent a great challenge to the abilities of our aircraft industry."

V/STOL

The XC-142A V/STOL transport mentioned earlier is the most promising to date in a long line of aircraft that are still lacking military application. The research, development, test and evaluation of the plane is expected to cost $119.6 million. It has been funded by all three military services, is now managed by the Air Force, and is in advanced development.

The tilt-wing LTV/Ryan/Hiller plane, five of which have been built, first flew as a conventional aircraft in September, 1964, and successfully transitioned from hovering to conventional flight Jan. 11. It would carry 32 combat-equipped troops or four tons at a cruise speed of more than 250 knots and a combat radius of 200 to 300 n. mi.

But as promising as the aircraft looks, the military has yet to generate a requirement for it or any of the other V/STOL planes. The two remaining tri-service-funded V/STOL aircraft with potential for boosting ground force mobility are the Bell Aerospace X-22 administered by the Navy and the Curtiss-Wright X-19A under Air Force administration. Two research craft of each type are being built, the X-22 at a cost of $31.5 million and the X-19A at $14.1 million.

OTHER AIRCRAFT

Two other aircraft of the short take-off and landing variety in advanced development deserve mention in considering Army mobility—the DeHavilland CV-7A Buffalo and the North American Aviation counterinsurgency light armed reconnaissance aircraft (COIN/LARA).

YOUR OWN

PEACEFUL TROPICAL ISLAND PARADISE ON GRAND BAHAMA!

Just 50 miles (80.5 km) across the Gulfstream from Palm Beach, Florida, lies beautiful tropical GRAND BAHAMA ISLAND.

Become part of the social and community life in the fastest growing island in the Bahamas. Grand Bahama has three 500-room hotels and more building...luxury apartment blocks . . . churches, schools, stores, businesses...medical, dental and hospital facilities ...two championship golf courses ...casino...cinemas...marinas... world-famous fishing and skin diving...and booming industrial Freeport. Over 20 scheduled flights daily from Florida, plus steamer service. Adjacent to all this growth on Grand Bahama Island, we are offering a limited number of choice homesites.
Choose yours now!

HOMESITES: *From $75 down — $75 on closing (within 90 days) balance from $15 monthly on mortgage note.

*Will accept any currency at its official bank conversion rate

• NO LAND TAXES • NO BAHAMAS INHERITANCE TAXES • NO RESTRICTIONS ON PERMANENT RESIDENCE ON YOUR OWN LAND • NO CLOSING COSTS • FREE DEED • FREE TITLE INSURANCE •

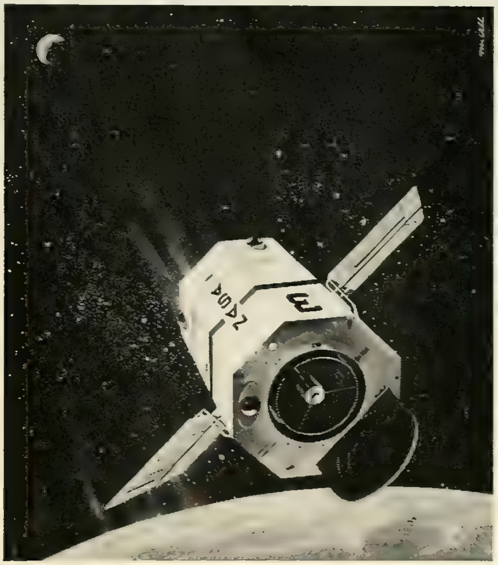
AIR MAIL COUPON NOW!

SUNSHINE REALTY
777 Metropolitan Miami Building
Dept. MR-7 , Miami, Fla 33132
PLEASE SEND FULL INFORMATION

Name________________
Address________________
City________________
State________ Zip Code________

Circle No. 6 on Subscriber Service Card

A telescope hurtling through space "anchored" on a base steadier than Mt. Palomar's?



Astronomical.

Yet true. The 22,000 part control system we developed for the Orbiting Astronomical Observatory (and successfully put through its dry runs) created entirely new design philosophies in satellite stabilization and control.

For a very good reason. To map the celestial sphere in 4 ultra-violet ranges and to accomplish the broadband photometry study of individual stars and nebulae, the 3,600 pound OAO must point its 1,000 pound instrument package with the accuracy and steadiness of earth-bound observatories undisturbed by seismic tremors.

Stiffer design requirements were posed than on any hardware yet launched. An extremely accurate celestially-oriented attitude control system must orient the astronomical telescope at any position in space with accuracies of one-tenth of a second of arc. (In terrestrial terms it's like finding a golf ball 20 miles away and tracking it for 45 minutes from a moving platform.) It will re-orient the main telescope through large angles quickly. And it is required to operate in space for one year with a 94 per cent probability of survival.

What does it all mean? Our staff of engineers, scientists and technicians at Valley Forge are doing some of the most sophisticated thinking around the aerospace industry today.

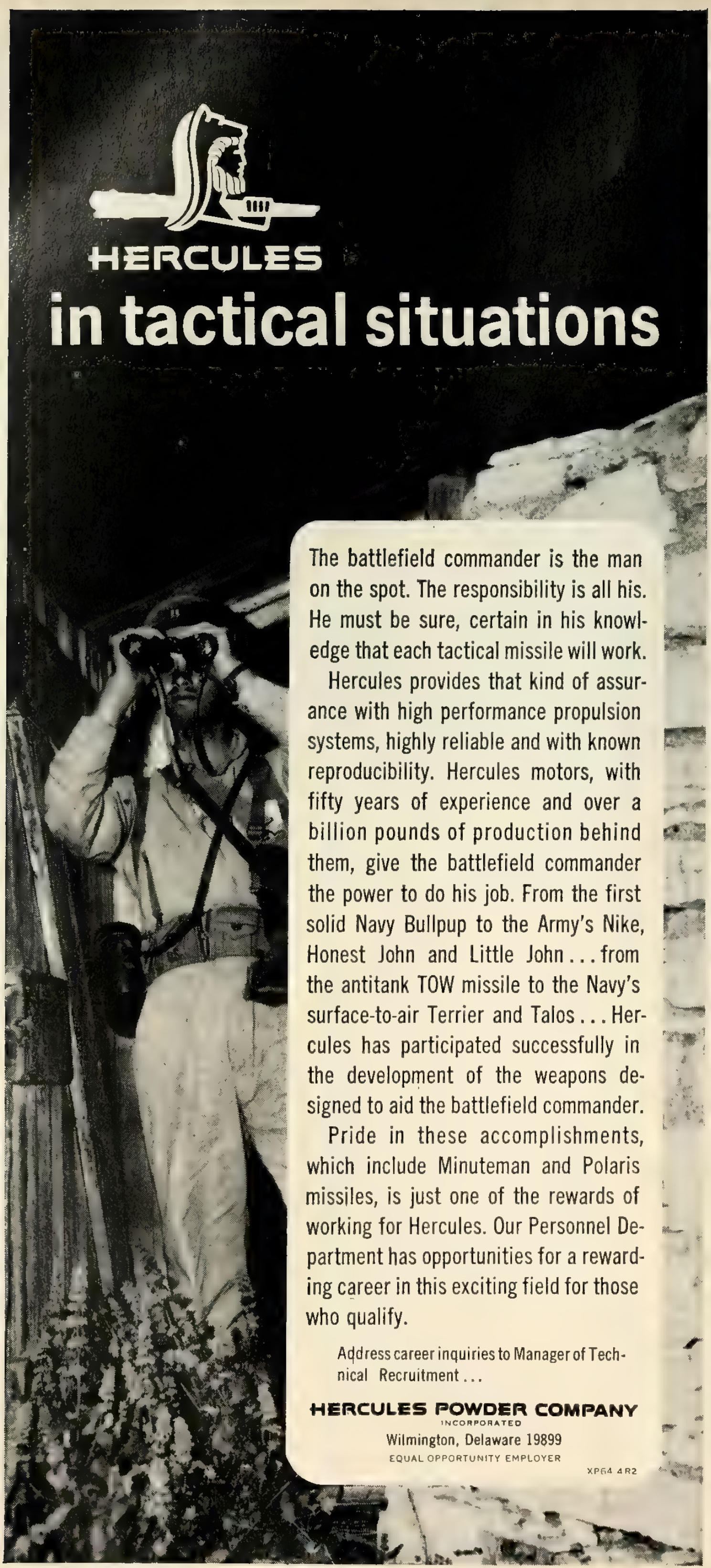
We're studying possible means for unmanned spacecraft exploration of Mars (Voyager). Not too long ago we simulated flight of 2 astronauts on a 15 day space mission, extending our knowledge of man's role in space (MOL). Another Gravity Gradient Stabilization System and another Nimbus will go up next. And our work is backed up by the most advanced, privately-owned space environment simulation facilities in the free world.

Interested?

You are invited to inquire further by writing to: Mr. J. S. Barson, Room 94-N, Spacecraft Dept., Valley Forge Space Technology Center, General Electric Co., P.O. Box 8555, Philadelphia, Pennsylvania. An equal opportunity employer.

MISSILE & SPACE DIVISION

GENERAL ELECTRIC


HERCULES
in tactical situations

The battlefield commander is the man on the spot. The responsibility is all his. He must be sure, certain in his knowledge that each tactical missile will work.

Hercules provides that kind of assurance with high performance propulsion systems, highly reliable and with known reproducibility. Hercules motors, with fifty years of experience and over a billion pounds of production behind them, give the battlefield commander the power to do his job. From the first solid Navy Bullpup to the Army's Nike, Honest John and Little John . . . from the antitank TOW missile to the Navy's surface-to-air Terrier and Talos . . . Hercules has participated successfully in the development of the weapons designed to aid the battlefield commander.

Pride in these accomplishments, which include Minuteman and Polaris missiles, is just one of the rewards of working for Hercules. Our Personnel Department has opportunities for a rewarding career in this exciting field for those who qualify.

Address career inquiries to Manager of Technical Recruitment . . .

HERCULES POWDER COMPANY
INCORPORATED
Wilmington, Delaware 19899
EQUAL OPPORTUNITY EMPLOYER

XP64 4R2

The CV-7A is a turbine-engine improvement over the DeHavilland CV-2B piston-engine Caribou, which carries 32 passengers or a four-ton payload. Four of the Buffaloes have been built at a cost of $22.5 million for RDT&E. The money has been provided by the Canadian Department of Defence, the U.S. Army and DeHavilland. Continued Army RDT&E support will be funded at a $2.4-million level in FY '66, but some DDR&E officials aren't optimistic about ultimate procurement because the Air Force C-130 may be made available for this light intra-theatre tactical transport requirement.

The Navy-funded COIN/LARA aircraft concept, according to one DDR&E official, is envisioned in a multi-purpose role (see p. 125). The plane is planned as both a weapons platform and a light cargo craft. In the latter category, it could carry something like two 55-gal. fuel drums for delivery or eight soldiers —either airborne or ground troops. Its short takeoff and landing features would allow this type of delivery to relatively primitive forward areas at high speeds.

SEA & AMPHIBIOUS MOBILITY

Besides the fast-deployment logistic ships mentioned earlier, two other principal developments are getting considerable attention in Navy and Marine Corps planning.

The Philadelphia Navy Yard is prototyping one World War II Landing Ship Tank (LST) under Bureau of Ships management to increase its speed from the World War II maximum of nine knots to 20 knots. The main problem to be solved is developing an unloading ramp over the sharper bow required to achieve the higher speed.

The other development is a landing force support vehicle, an amphibian to replace the World War II DUKW. An experimental version developed by Anti-Friction Hull Corp., Severna Park, Md. (illustrations, p. 120), is undergoing tests. Present landing craft can travel only six to 10 knots. The Anti-Friction Hull Corp. Hydrokeel type [designated ARC(K)], which has strong Marine Corps support, would be able to deliver the 30 to 40-knot speeds required.

Besides funds for the landing force support vehicle, the Navy has asked for $494 million in FY '66 to build 15 amphibious assault ships—LSD's (Landing Ship Dock), LST's, LPD's (Amphibious Transport Dock) and LPS's (Amphibious Assault Ship).

ARMY SURFACE MOBILITY

The Army Mobility Command, with headquarters in Warren, Mich., plans to spend $0.5 billion for R&D "in upcoming years," according to its commander, Maj. Gen. Lapsley. Lapsley has said that 80% of this money would go to

Circle No. 5 on Subscriber Service Card

industry for implementation of R&D.

- **Vehicle features sought**—Spokesmen in the Army Materiel Command summarized surface mobility R&D efforts by saying that the Army is continually striving to lighten the weight, improve the air transportability, double the cross-country speeds and lessen the ground pressures of all its forward area vehicles, both wheeled and tracked. An amphibious capability has also been found desirable for as many types of vehicles as possible to improve the cross-country travel in terrain that includes the streams and muddy surfaces typical of South Viet Nam.

DDR&E officials commenting on Army surface mobility stressed that of three kinds of vehicles under study—articulated joint types, marsh screw vehicles and ground-effects machines or air-cushion vehicles—the articulated joint concept is the farthest along in development and will be procured.

The best example to date of successful application of the articulated joint is in the 1¼-ton XM-561 cargo or troop truck (photo, p. 118). The articulated coupling joins the truck and trailer. It allows each of the units to twist and bend independently, yet power and braking are transmitted to the rear wheels through the coupling.

The vehicle is an outgrowth of the Gama Goat, an in-house Ling-Temco-Vought development. The Army expects the vehicle to enter the inventory within a few years. It would represent a procurement contract worth more than $50 million.

- **Unique terrain description**—An Army Materiel Command study to more precisely relate vehicle design to terrain features likely to be encountered is being conducted by the Army Corps of Engineers' Waterways Experiment Station, Vicksburg, Miss.

Inputs from five categories are required to arrive at a mathematical definition of the terrain in a given area.

The categories considered are:

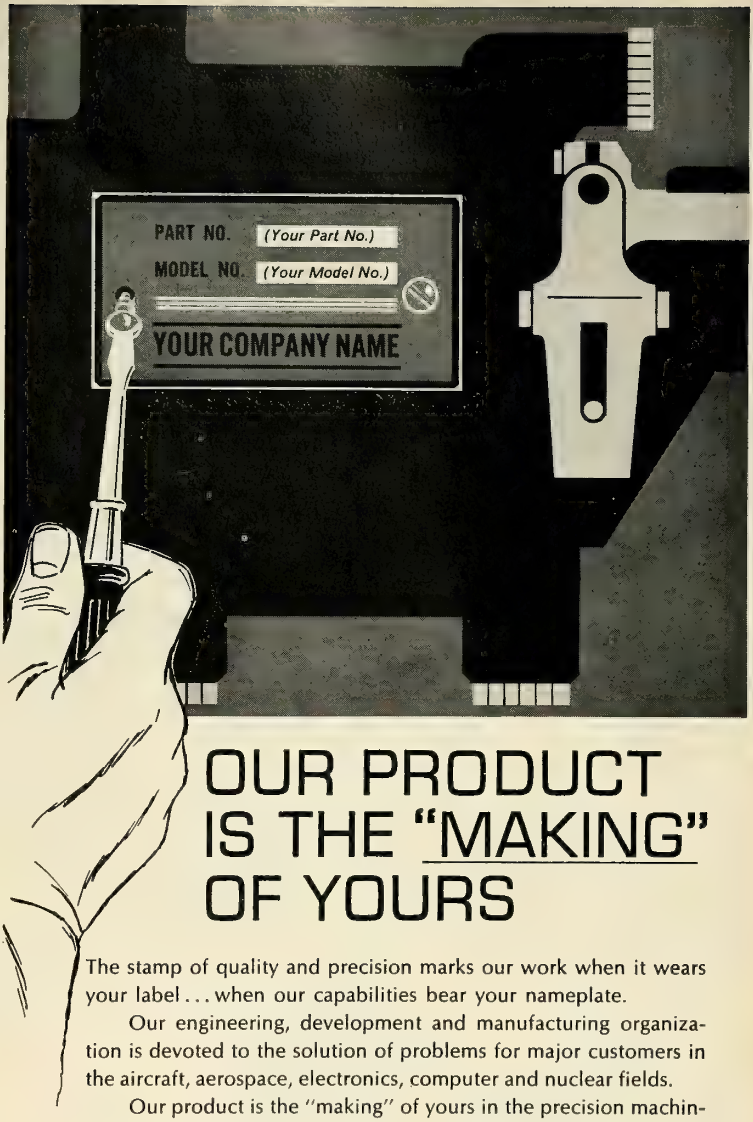
1) Surface geometry—The roughness of the terrain is described mathematically.

2) Surface consistency—Soil mechanics information is cranked into the quantitive terrain description.

3) Vegetation—An attempt is made to sample the terrain and quantify the engineering properties of the growth.

4) Hydraulic geometry—This is the term used to mathematically describe the characteristics of a stream, including the heights of the stream bank, velocity of water flow and water depth.

5) Climatology—Although weather information has been collected for some time over large parts of the Earth, it is important to know the duration of such phenomena as rain and temperature extremes. ■


PART NO.
(Your Part No.)
MODEL NO.
(Your Model No.)
YOUR COMPANY NAME

OUR PRODUCT IS THE "MAKING" OF YOURS

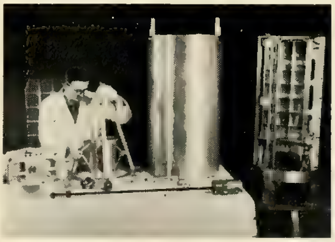
The stamp of quality and precision marks our work when it wears your label . . . when our capabilities bear your nameplate.

Our engineering, development and manufacturing organization is devoted to the solution of problems for major customers in the aircraft, aerospace, electronics, computer and nuclear fields.

Our product is the "making" of yours in the precision machining of standard and exotic materials . . . the fabrication of complex tools and gages . . . and in the development and manufacturing of prototype or production quantities of special components and devices ranging from automotive to aerospace.

The facilities and personnel of Mechanical Specialties are cleared for DOD and AEC classified projects.

Write for further information and new descriptive brochure.



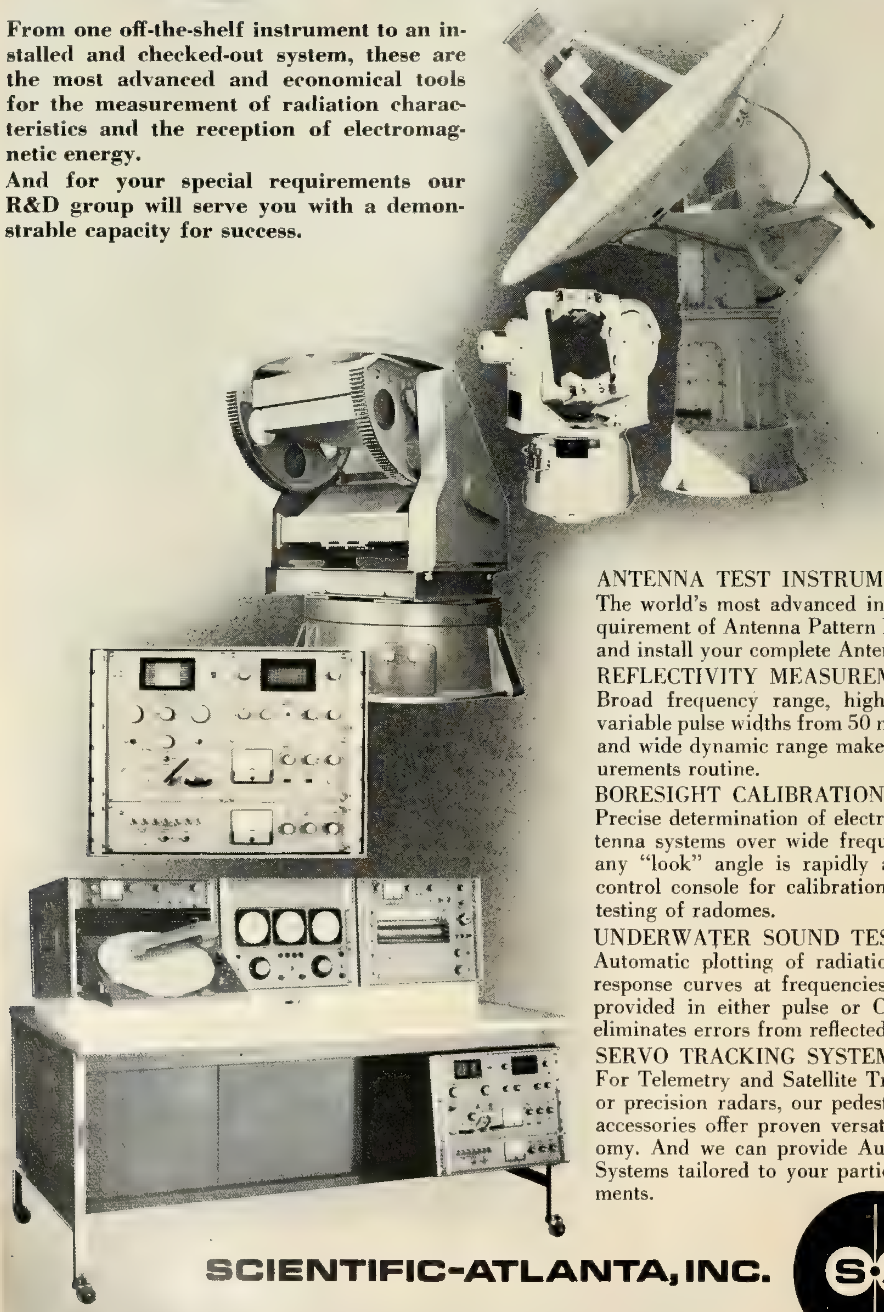
MECHANICAL SPECIALTIES COMPANY
5700 WEST 96th STREET, LOS ANGELES, CALIFORNIA 90045
"the aerospace mechanical laboratory"

Circle No. 4 on Subscriber Service Card

S·A is the ABZ of radiation measurements

From one off-the-shelf instrument to an installed and checked-out system, these are the most advanced and economical tools for the measurement of radiation characteristics and the reception of electromagnetic energy.

And for your special requirements our R&D group will serve you with a demonstrable capacity for success.



ANTENNA TEST INSTRUMENTS:
The world's most advanced instruments satisfy every requirement of Antenna Pattern Ranges. And we will design and install your complete Antenna Test Facility.

REFLECTIVITY MEASUREMENT SYSTEMS:
Broad frequency range, high sensitivity and linearity, variable pulse widths from 50 nsec and PRF from 500 pps, and wide dynamic range make accurate backscatter measurements routine.

BORESIGHT CALIBRATION SYSTEMS:
Precise determination of electromagnetic boresight of antenna systems over wide frequency ranges and virtually any "look" angle is rapidly accomplished from central control console for calibration of radars and acceptance testing of radomes.

UNDERWATER SOUND TEST INSTRUMENTS:
Automatic plotting of radiation patterns and frequency response curves at frequencies from 50 cps to 2 Mc is provided in either pulse or CW modes. Gated receiver eliminates errors from reflected signals.

SERVO TRACKING SYSTEMS:
For Telemetry and Satellite Tracking, Radio Astronomy, or precision radars, our pedestals, solid state servos, and accessories offer proven versatility, reliability, and economy. And we can provide Automatic Tracking Antenna Systems tailored to your particular performance requirements.

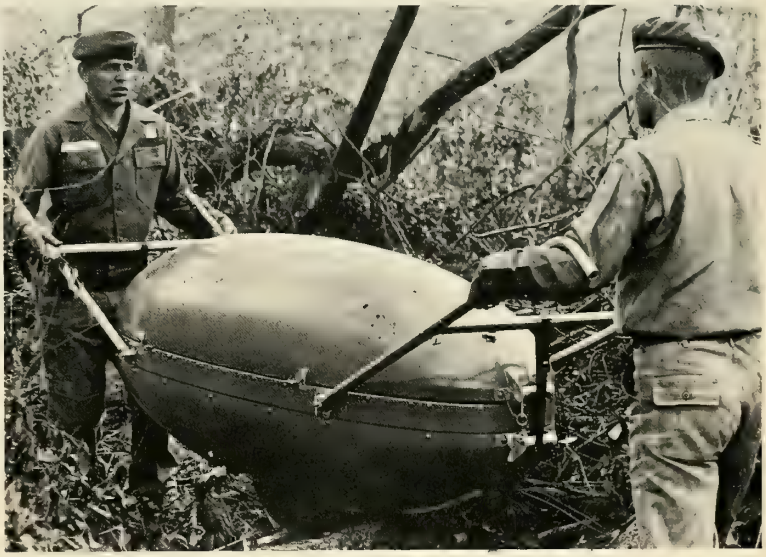
SCIENTIFIC-ATLANTA, INC. S·A

Box 13654, Atlanta, Georgia 30324 Tel. 404-938-2930
TWX-810-766-4912 WUX: PSO Cable: SCIATLA

Circle No. 16 on Subscriber Service Card

R&D Funding Continues To Increase

McNamara cites guerrilla war as most critical threat to U.S. through 1970; surveillance of enemy represents biggest problem



MAN-PROPELLED device developed by Army Limited War Lab, Aberdeen Proving Ground, Md., would carry 250-lb. payload of a squad's weapons, ammunition and rations.

THE DEFENSE DEPARTMENT has requested $160 million for research and development funds in FY'66 to conduct counterinsurgency programs.

DOD officials believe that funding for these programs—on the rise since 1960—will continue to increase.

Secretary of Defense Robert S. McNamara has called insurgency the greatest threat to this nation's security in the last half of this decade.

About $25 million of the total will be spent by a special Directorate of Defense Research and Engineering research group called Agile. Another $6 million will be spent by the Air Force to develop the new counterinsurgency Light Armed Reconnaissance Aircraft, (LARA), with most of the remaining funds being spent by various U.S. Army agencies.

The money is being spent on a variety of new systems developed through advanced technology such as hand-held radars, seismic and magnetic detection devices, image intensification instruments, a radio with a 1,500-mi. range, survival packs, and airborne firing and surveillance systems.

All are designed to meet the technical problems met by U.S. forces operating far from their home bases attempting to aid indigenous troops in repelling aggression by guerrilla forces.

• **Surveillance toughest problem**—At the present time, all of the groups involved in developing better counterinsurgency systems are putting a great deal of their effort into the toughest problem faced in such a conflict, adequate surveillance of the enemy.

While several systems are in the testing stage, none promises to solve the problem. Suggestions by industry and universities for other concepts will find a receptive audience at Agile and Army R&D.

The systems tried so far use such concepts as magnetic fields and seismic infrared and hand-held radars, and stationary short-, medium- and long-distance radars.

The magnetic field approach, according to Army experts, seems to have greatest possibilities, primarily because the magnetic sensor provides a positive identification of metal—something an infiltrating guerrilla is almost certain to have on his person.

Magnetic devices tested so far—when buried in the ground—have been able to detect amounts of metal as light as one pound.

Seismic devices planted in the ground along jungle trails pick up vibrations and register them on an electronic device. They have been successfully used up to a range of 25-30 yds.

Seismic systems and radars have a deficiency in their inability to differentiate between a man or animal.

• **Hand-held radar finds favor**—DOD officials are so enthusiastic about the new hand-held radar concept that they now have two firms building prototype systems. The system that has already been tested, however, has proved too complex for the average soldier.

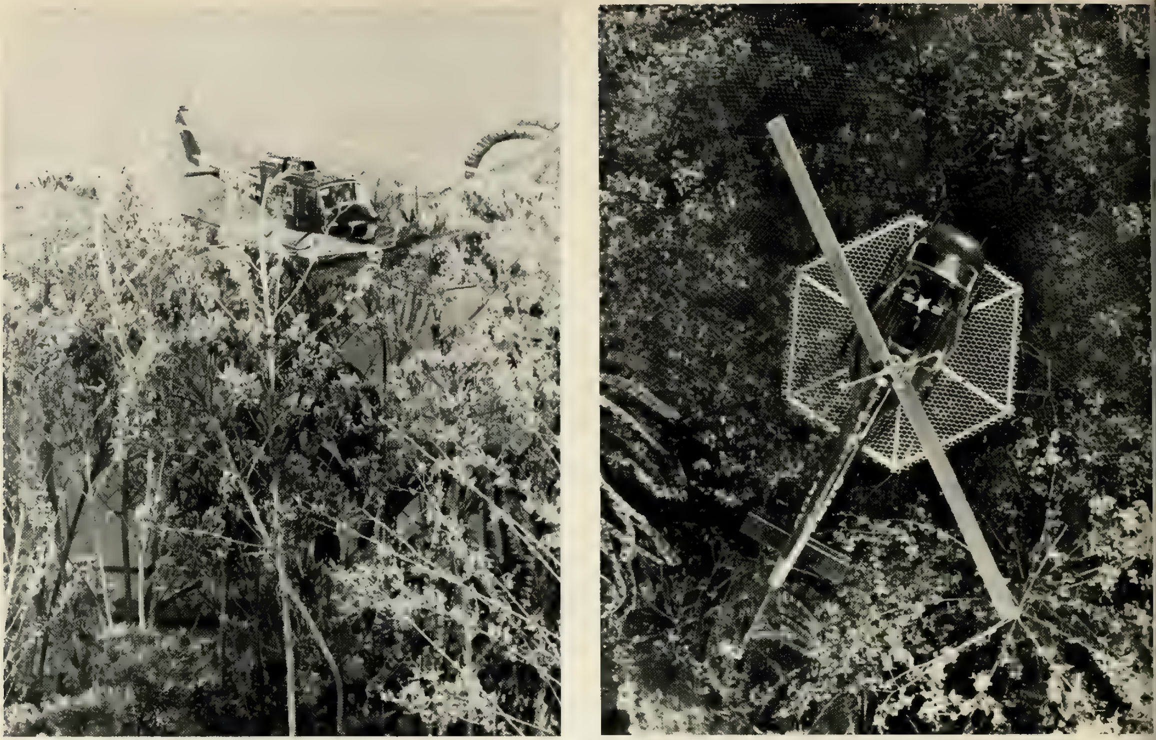
DOD hopes that any new system will be simpler, lighter and have a longer range than the current one. Also, the system being tested is not truly hand-held. In order to improve its accuracy, it is mounted on a small tripod while in use.

The new radar—which weighs only about 10 lbs.—was made possible by advances in solid-state technology. While it could be applied to all types of conflicts, it would be especially important in counterinsurgency wars where infiltration is a threat.

The radar is designed to detect and locate moving targets. The targets detected are presented to the operator through a combination of signals.

The one limitation DOD would like to see industry lick is the line-of-sight limitation on any ground-based radar. Such a hand-held radar cannot penetrate the jungle or even look around a hill.

• **Heat-seeking surveillance**—Agile and the Army are currently cooperating with the Air Force in the development



MODEL CANOPY PLATFORM shown here in two views is designed to be lowered into jungle to form a staging platform atop jungle growth for off-loading of troops and materiel, and for evacuation of casualties.

of photographic airborne surveillance techniques. One system currently being used is the infrared sensor which seeks out heat sources, such as campfires, to determine where the enemy is. While this has worked fairly successfully in Viet Nam, it is not effective if the campfires are extinguished.

A DOD official said that radar and infrared devices give the U.S. Army a capability similar to a man seeing a shadow. What we really need, he said, is a breakthrough in resolution so that they will give us a photographic presentation.

One new technology promising a breakthrough is light-intensification devices.

Light-intensification devices can be used to improve night vision, as a weapons sight and as an observation telescope for long-range viewing. By intensifying natural light sources, such as the Moon and stars, thousands of times, they achieve the ability to project an image that is clearly visible.

Light-intensification devices utilize miniature image intensification tubes and transistorized high-voltage power supplies.

There are three currently operating systems that have been tested by troops in the field and yielded good results. The Army, however, would like to develop simple and more effective systems.

The three systems are:

—The starlight scope, which weighs less than 6 lbs. and can be mounted on standard military rifles.

—The crew-served weapons night vision sight weighs less than 20 lbs. and can be mounted on machine guns and recoilless rifles.

—A medium-range night observation device, which weighs slightly more than 40 lbs., is mounted on a tripod, and can be used for standard battlefield use.

• **Ambush**—The one major problem in counterinsurgency warfare that has thus far defied application of any mechanical detection means is the ambush.

Early in the Viet Nam war, the Viet Cong, because of their poor weapons, had to set up ambush operations close to the roads. They were also susceptible to discovery by helicopters flying overhead. As a result, they could be countered fairly easily by the South Vietnamese.

Recently they have been supplied with such weapons as recoilless rifles and antiaircraft equipment, which permits them to set up an ambush quite a distance away from their target. The U.S., in turn, has made some highly classified changes in Army vehicles, including the development of lighter armor, which it feels will make them less susceptible to incoming fire as well as more effective in taking offensive action against the enemy.

One major new weapons system now under development is the counterinsurgency Light Armed Reconnaissance Aircraft. The Navy is directing the program, which calls for seven prototypes to be built at a total cost of $18 million.

About $6 million has been requested in the FY '66 budget. North American Aviation, Inc., has been selected to build the plane, which will be able to carry up to eight men. Its reconnaissance and weapons systems are classified.

• **AAFSS and V/STOL**—Another new project, which will be used for counterinsurgency as well as limited-type wars, is the Advanced Aerial Fire Support System (AAFSS). About $5 million will be reprogrammed in FY '65 funds to fund the program definition phase, and initial funds for engineering development totaling $17.3 million are included in next year's budget request.

The system will include either advanced V/STOL or compound helicopter frames capabile of maximum speeds of 200 knots, new integrated helicopter avionics systems, new fire-control techniques, and the use of new aerial weapons such as high-rate-of-fire machine guns.

The system will be used for tactical

TWO GREAT NEW CHAMPS

NEW COAX

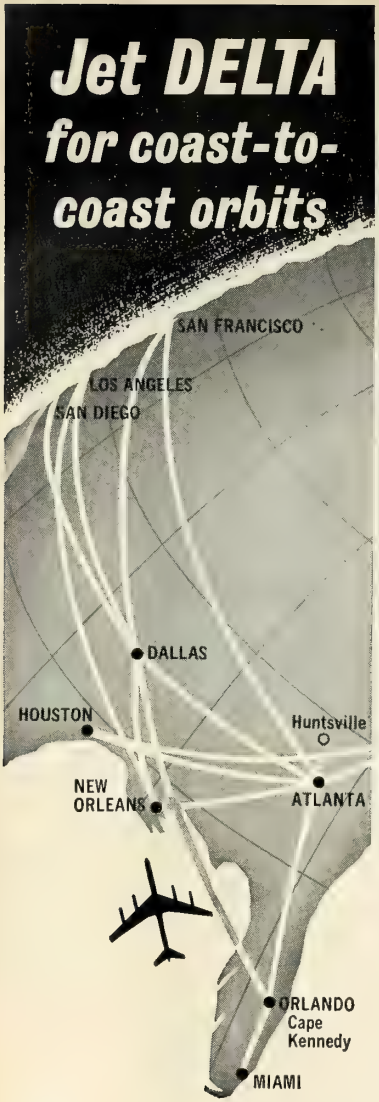
Recording 1.5 mc on as many as fourteen tracks, Mincom's new Portable Coaxial Recorder offers the industry's highest performance per cubic foot. Stands under two feet high. 14-inch NAB precision reels. 1⅞ to 120 ips. Two playback channels. RFI-shielded, this new system is unequalled for van, shipboard and similar installations.

NEW PCM

Digital data in an improved parallel format at 120,000 bits per second per track—that's the story of Mincom's newest solid-state system. Sixteen channels for NRZ digital input, clock, timing and voice. Seven push-button speeds from 1⅞ to 120 ips. Controls and adjustments front-accessible for CRT display and digital electronics.

Mincom Division 3M COMPANY
300 South Lewis Road, Camarillo, California

Circle No. 15 on Subscriber Service Card



The only thru Jets between California and Atlanta-Orlando/Cape Kennedy

- 15 Jet flights daily between Dallas and California
- Round trip tourist fare, 7-22 days, Orlando-Los Angeles $220; Orlando-San Francisco only $240. *Add tax to airfares*

Call Delta or see your Travel Agent

DELTA®

the air line with the BIG JETS

BALLOON-BORNE communications are under study to overcome high signal attenuation through jungle vegetation that limits VHF communications to a very short range.

support of ground troops and support fire for helicopter landing of troops.

- **Agile**—The real think factory in the use of advanced technology for counterinsurgency conflicts is Agile.

Agile was established in 1961 to determine what special problems counterinsurgency wars presented for U.S. forces and then to mobilize the research needed to solve them.

The group's job is to find out from the service involved the nature of the problem. It then contracts with either industry or universities in an effort to find a solution. If a solution is found, it is turned over to the service, which then initiates procurement through its normal channels.

Currently, most of Agile's work involves finding solutions to combat problems involved in the U.S. attempt to defend the independence of South Viet Nam against the North Vietnamese.

- **Radio problems**—One major problem encountered by U.S. forces in South Viet Nam is that radio communication through the jungle is not the same as under normal conditions. The low-frequency radios used by U.S. advisors seemed unable to do the job.

Although industry has come up with some new equipment, Agile believes it remains a problem and further research contracts are expected to be awarded in this area.

Some solutions tried so far include higher radio frequencies, skyway propagation and antenna re-orientation.

Test quantities of new hardware have been introduced in Viet Nam and have worked well. The current study contracts are expected to end early next year and new ones will then be awarded. Agile is spending about $2.5 million per year in radio communications.

Another urgent requirement for radio communications is for a lightweight power source that can be carried by a man for a long time even under severe conditions.

One temporary solution to the communications problem has been the modification of the radio set AN/PRC-52 to high frequency for jungle use. The new version is called the AN/PRC-64. It operates in the frequency range of 2.5-6 mc. It measures 9x5x3½ in. and weighs approximately 10 lbs. with carrying case and all accessories including one extra battery. The set was primarily developed for CW or code, but it also has a voice capability. By switching an additional amplification to the microphone, the operator can whisper in tactical situations in the jungle where normal voice would be undesirable. Specially constructed for use in the jungle environment, the radio, in a closed position, is completely immersion proof. Preliminary tests have resulted in voice communications in excess of 150 mi.

The Army and DDR&E believe the long-term solution to radio problems in the jungle and other areas where counterinsurgency wars may erupt will be filled by a new radio it hopes to develop by 1970.

Design specifications call for the set to have a single sideband, AM, FM, CW and a frequency shift key. Its range for line-of-sight communications will be 25 mi. and with CW, about 1,500 mi. A prototype set is now being developed and the total development time is expected to be four years. Such a lead time means that the radio will have to go into development by 1966, and the use of FY '66 funds is likely.

- **Low-maintenance vehicles**—Another major problem in counterinsurgency conflicts is the frequent lack of trained maintenance people. One possible solution—to which advanced technology could be applied by American industry—is the development of a maintenance-free ground vehicle.

Feasibility studies are currently being awarded in this area, and Agile officials believe that development of such a vehicle is a good possibility. While the eventual solution may be only a low-maintenance vehicle, the technology could be applied across the board on almost all ground vehicles, such as trucks, jeeps, armored personnel carriers and tanks.

- **Human and environmental factors**—Looking to the future, Agile is awarding contracts in such areas as urban insurgency, human factors and environmental conditions.

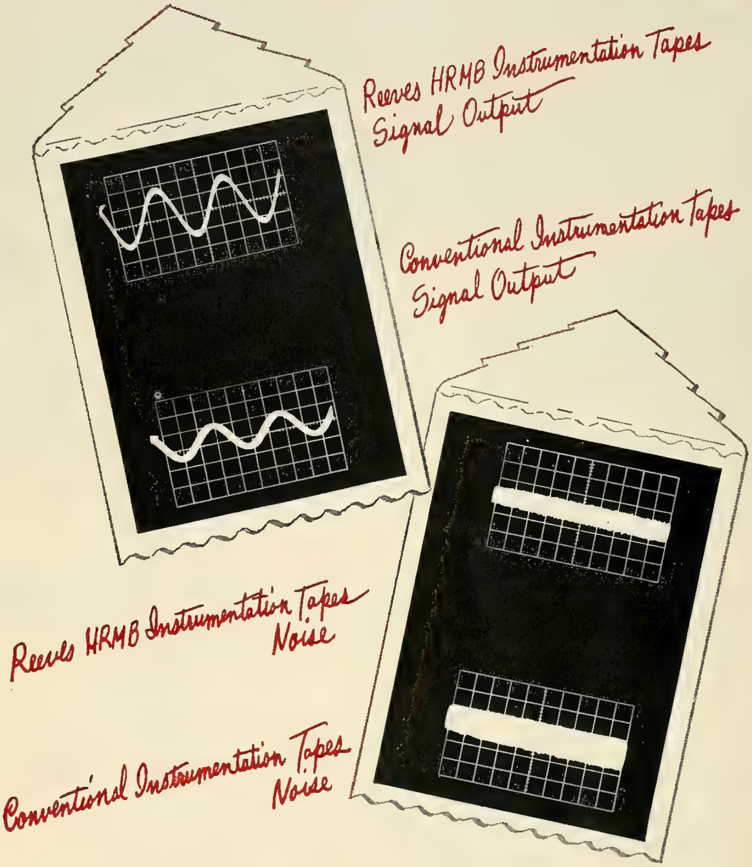
As the U.S. counterinsurgency effort has grown, DOD has begun to realize more and more that, despite the special weapons that are developed, the key to such a war is the people involved.

As a result, Agile is now studying areas of the world where they feel future wars may start. In these studies, research surveys are made of the capabilities of the populations of various countries. The surveys involve studies of their dietary habits, problems in cross-cultural relationships, and how values differ from those of Americans.

Environmental conditions such as weather, terrain, and soil composition are also studied. Soil characteristics, for example, can have considerable impact on maneuverability.

Attention is being given to urban insurgency because if the U.S. became involved in aiding a friendly foreign power in such a struggle, it would present a whole new set of problems in counterinsurgency weapons and systems. ■

SEE WHY THE NEW REEVES INSTRUMENTATION TAPES ARE THE ONLY TAPES YOU CAN AFFORD TO USE?


Reeves HRMB Instrumentation Tapes
Signal Output
Conventional Instrumentation Tapes
Signal Output
Reeves HRMB Instrumentation Tapes
Noise
Conventional Instrumentation Tapes
Noise

This dramatic advance in performance is the result of Type HRMB's special oxide and binder system combined with MICRO-PLATE* — Reeves Soundcraft's exclusive new process which produces the smoothest surface in a tape today.

In addition to its better signal output and noise characteristics, Type HRMB offers these improvements over conventional instrumentation tapes:

• Lower distortion • Freedom from shedding (oxide and binder are locked together) • Lower head temperatures and less abrasiveness — assuring longer head and tape life • Higher electrostatic conductivity for uniform static drain.

Available in "A" oxide for normal bandwidth applications—"B" oxide for extended bandwidth applications. Write for new Reeves Soundcraft Instrumentation Tape brochure.

Polaroid photos are actual tests of tapes run on Sangamo Model No. 4742 recorder reproduce system.

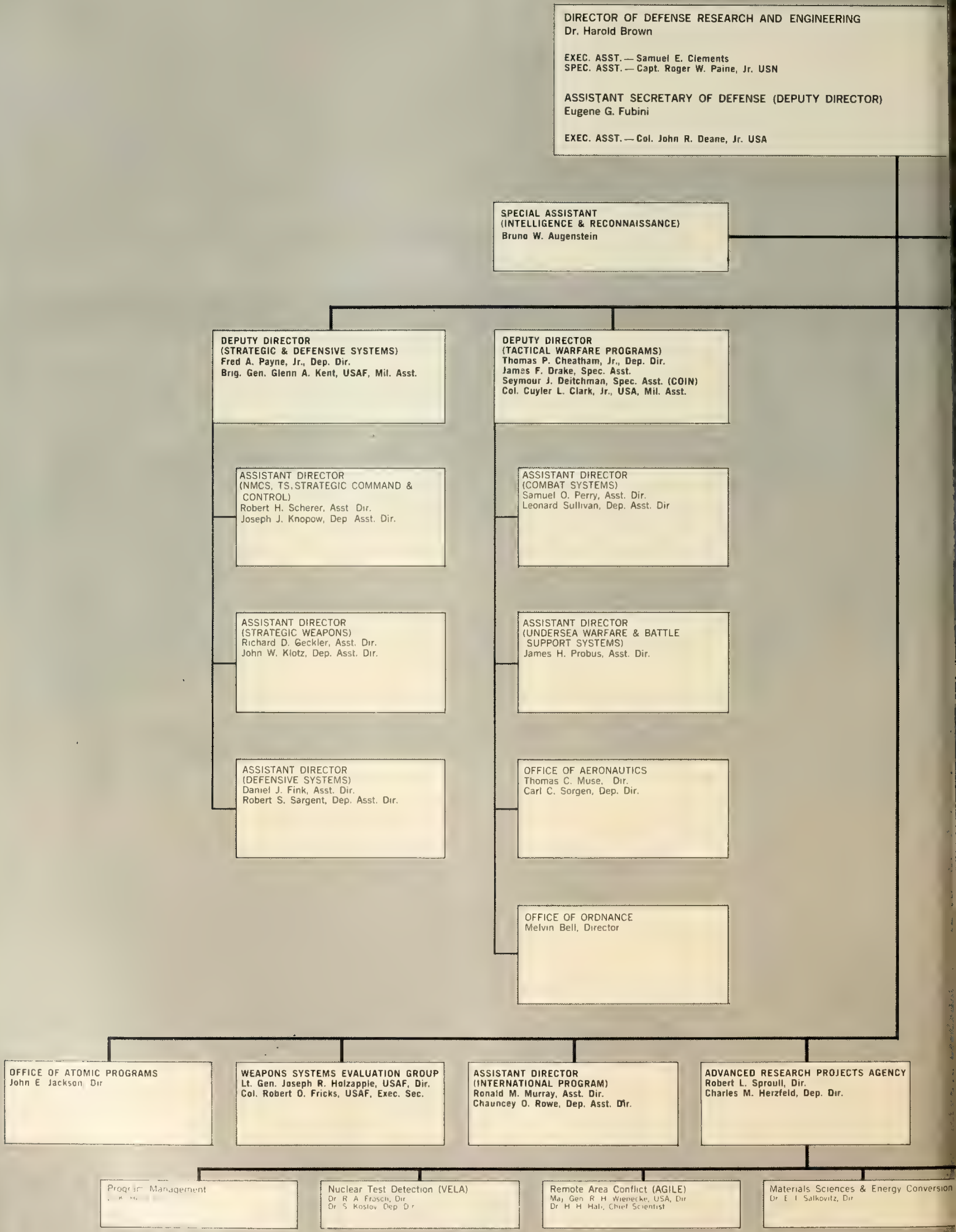
*Reeves Soundcraft T.M.

REEVES SOUNDCRAFT
DIVISION OF REEVES INDUSTRIES INC.
GREAT PASTURE ROAD, DANBURY, CONN.

New York • Chicago • Los Angeles • Export: C.B.S. International, 46 E. 52 St., N.Y.C. • Canadian Reps: Toronto

Circle No. 14 on Subscriber Service Card

DEFENSE RESEARCH AND ENGINEERING



DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
Dr. Harold Brown

EXEC. ASST.—Samuel E. Clements
SPEC. ASST.—Capt. Roger W. Paine, Jr. USN

ASSISTANT SECRETARY OF DEFENSE (DEPUTY DIRECTOR)
Eugene G. Fubini

EXEC. ASST.—Col. John R. Deane, Jr. USA

SPECIAL ASSISTANT
(INTELLIGENCE & RECONNAISSANCE)
Bruno W. Augenstein

DEPUTY DIRECTOR
(STRATEGIC & DEFENSIVE SYSTEMS)
Fred A. Payne, Jr., Dep. Dir.
Brig. Gen. Glenn A. Kent, USAF, Mil. Asst.

ASSISTANT DIRECTOR
(NMCS, TS, STRATEGIC COMMAND & CONTROL)
Robert H. Scherer, Asst Dir.
Joseph J. Knopow, Dep Asst. Dir.

ASSISTANT DIRECTOR
(STRATEGIC WEAPONS)
Richard D. Geckler, Asst. Dir.
John W. Klotz, Dep. Asst. Dir.

ASSISTANT DIRECTOR
(DEFENSIVE SYSTEMS)
Daniel J. Fink, Asst. Dir.
Robert S. Sargent, Dep. Asst. Dir.

DEPUTY DIRECTOR
(TACTICAL WARFARE PROGRAMS)
Thomas P. Cheatham, Jr., Dep. Dir.
James F. Drake, Spec. Asst.
Seymour J. Deitchman, Spec. Asst. (COIN)
Col. Cuyler L. Clark, Jr., USA, Mil. Asst.

ASSISTANT DIRECTOR
(COMBAT SYSTEMS)
Samuel O. Perry, Asst. Dir.
Leonard Sullivan, Dep. Asst. Dir

ASSISTANT DIRECTOR
(UNDERSEA WARFARE & BATTLE SUPPORT SYSTEMS)
James H. Probus, Asst. Dir.

OFFICE OF AERONAUTICS
Thomas C. Muse, Dir.
Carl C. Sorgen, Dep. Dir.

OFFICE OF ORDNANCE
Melvin Bell, Director

OFFICE OF ATOMIC PROGRAMS
John E Jackson, Dir

WEAPONS SYSTEMS EVALUATION GROUP
Lt. Gen. Joseph R. Holzapple, USAF, Dir.
Col. Robert O. Fricks, USAF, Exec. Sec.

ASSISTANT DIRECTOR
(INTERNATIONAL PROGRAM)
Ronald M. Murray, Asst. Dir.
Chauncey O. Rowe, Dep. Asst. Dir.

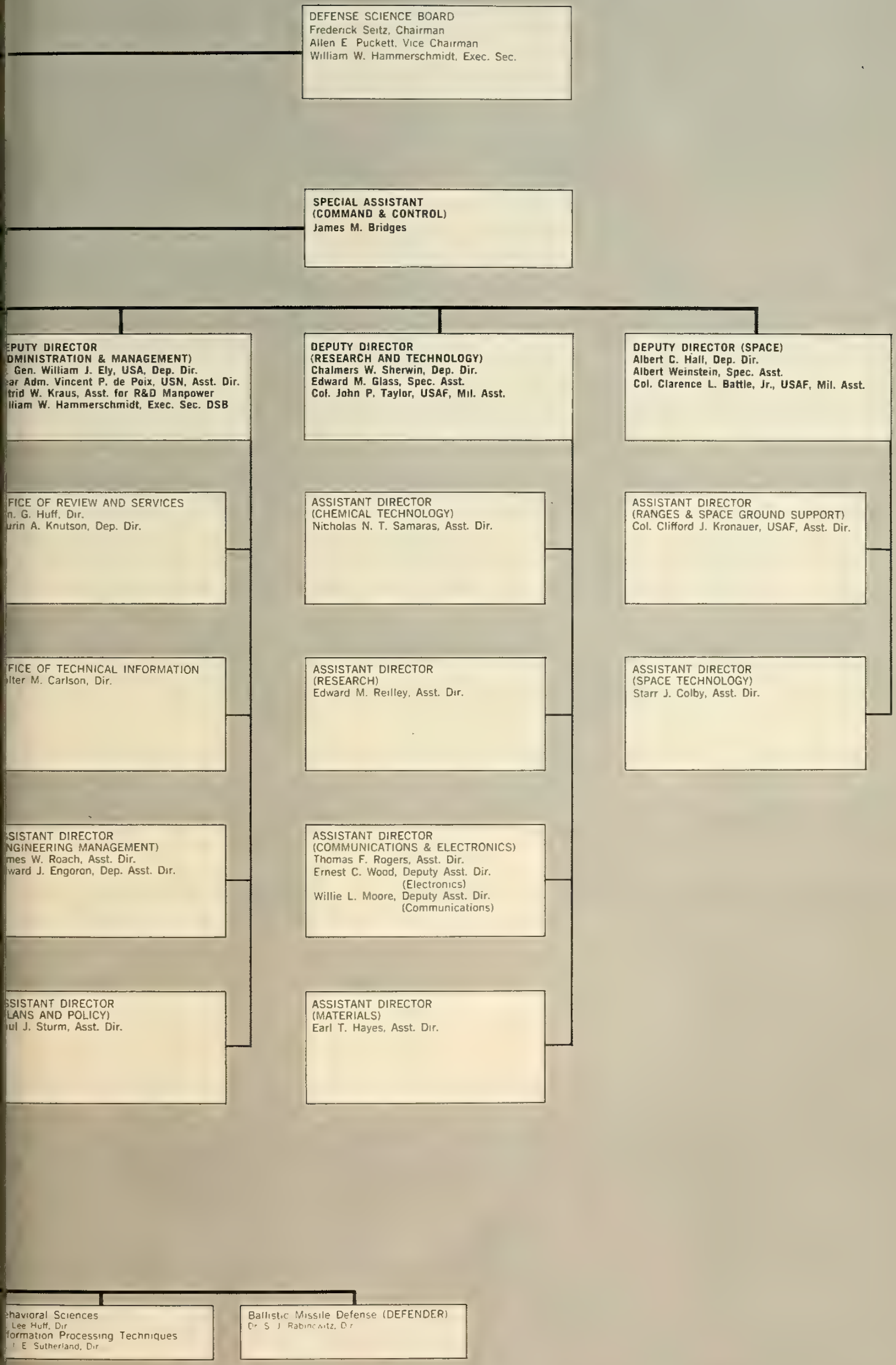
ADVANCED RESEARCH PROJECTS AGENCY
Robert L. Sproull, Dir.
Charles M. Herzfeld, Dep. Dir.

Program Management
[illegible]

Nuclear Test Detection (VELA)
Dr R A Frosch, Dir
Dr S Koslov Dep Dir

Remote Area Conflict (AGILE)
Maj Gen R H Wienecke, USA, Dir
Dr H H Hall, Chief Scientist

Materials Sciences & Energy Conversion
Dr E I Salkovitz, Dir



DEFENSE SCIENCE BOARD
Frederick Seitz, Chairman
Allen E. Puckett, Vice Chairman
William W. Hammerschmidt, Exec. Sec.

SPECIAL ASSISTANT
(COMMAND & CONTROL)
James M. Bridges

PUTY DIRECTOR
DMINISTRATION & MANAGEMENT)
Gen. William J. Ely, USA, Dep. Dir.
ar Adm. Vincent P. de Poix, USN, Asst. Dir.
trid W. Kraus, Asst. for R&D Manpower
lliam W. Hammerschmidt, Exec. Sec. DSB

FICE OF REVIEW AND SERVICES
n. G. Huff, Dir.
urin A. Knutson, Dep. Dir.

FICE OF TECHNICAL INFORMATION
lter M. Carlson, Dir.

SISTANT DIRECTOR
NGINEERING MANAGEMENT)
mes W. Roach, Asst. Dir.
ward J. Engoron, Dep. Asst. Dir.

SSISTANT DIRECTOR
LANS AND POLICY)
ul J. Sturm, Asst. Dir.

DEPUTY DIRECTOR
(RESEARCH AND TECHNOLOGY)
Chalmers W. Sherwin, Dep. Dir.
Edward M. Glass, Spec. Asst.
Col. John P. Taylor, USAF, Mil. Asst.

ASSISTANT DIRECTOR
(CHEMICAL TECHNOLOGY)
Nicholas N. T. Samaras, Asst. Dir.

ASSISTANT DIRECTOR
(RESEARCH)
Edward M. Reilley, Asst. Dir.

ASSISTANT DIRECTOR
(COMMUNICATIONS & ELECTRONICS)
Thomas F. Rogers, Asst. Dir.
Ernest C. Wood, Deputy Asst. Dir.
(Electronics)
Willie L. Moore, Deputy Asst. Dir.
(Communications)

ASSISTANT DIRECTOR
(MATERIALS)
Earl T. Hayes, Asst. Dir.

DEPUTY DIRECTOR (SPACE)
Albert C. Hall, Dep. Dir.
Albert Weinstein, Spec. Asst.
Col. Clarence L. Battle, Jr., USAF, Mil. Asst.

ASSISTANT DIRECTOR
(RANGES & SPACE GROUND SUPPORT)
Col. Clifford J. Kronauer, USAF, Asst. Dir.

ASSISTANT DIRECTOR
(SPACE TECHNOLOGY)
Starr J. Colby, Asst. Dir.

ehavioral Sciences
Lee Huff, Dir
formation Processing Techniques
I E Sutherland, Dir

Ballistic Missile Defense (DEFENDER)
Dr S J Rabinowitz, Dir

Here's what it takes to service present radars in a typical fighter squadron

Circle No. 17 on Subscriber Service Card

but the new Westinghouse AWG-10 radar cuts maintenance costs in half

The remarkable AWG-10 missile control system is a new breed of the famous Westinghouse line of airborne fire control radars. The AWG-10 is being built for the F4. It is a multimission system with true versatility in range and tracking ability, terrain avoidance, follow and mapping. The system performed successfully its initial test flights in late 1964.

The reliability of the AWG-10 is more than twice that of any system now in use. It requires fewer flight line personnel per squadron and far less turn-around time per aircraft. Maintenance costs are reduced by as much as 50 per cent.

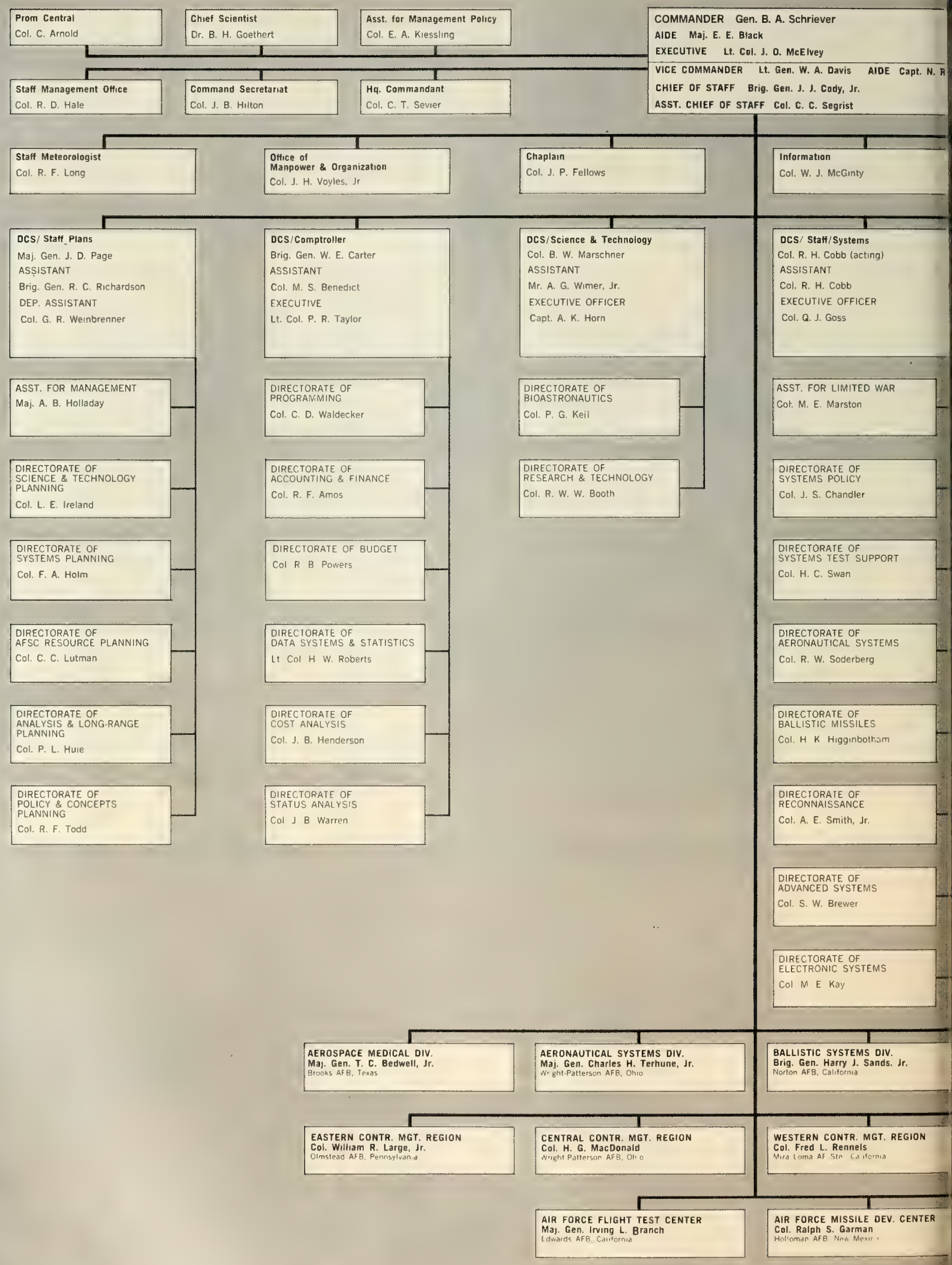
Replaceable line units are preset, require no system realignment or tuning. Extensive built-in tests which isolate faults and speed corrective action were pioneered by Westinghouse, the world's most experienced builder of airborne radars. Information is available only on confirmation of your need-to-know through proper security channels. Write to Westinghouse Electric Corporation, Aerospace Division, Box 746, Baltimore 3, Maryland.

J-02376

You can be sure if it's Westinghouse

Circle No. 17 on Subscriber Service Card

AIR FORCE SYSTEMS COMMAND



COMMANDER Gen. B. A. Schriever
AIDE Maj. E. E. Black
EXECUTIVE Lt. Col. J. O. McElvey
VICE COMMANDER Lt. Gen. W. A. Davis **AIDE** Capt. N. R
CHIEF OF STAFF Brig. Gen. J. J. Cody, Jr.
ASST. CHIEF OF STAFF Col. C. C. Segrist

Prom Central
Col. C. Arnold

Chief Scientist
Dr. B. H. Goethert

Asst. for Management Policy
Col. E. A. Kiessling

Staff Management Office
Col. R. D. Hale

Command Secretariat
Col. J. B. Hilton

Hq. Commandant
Col. C. T. Sevier

Staff Meteorologist
Col. R. F. Long

Office of Manpower & Organization
Col. J. H. Voyles, Jr

Chaplain
Col. J. P. Fellows

Information
Col. W. J. McGinty

DCS/ Staff Plans
Maj. Gen. J. D. Page
ASSISTANT
Brig. Gen. R. C. Richardson
DEP. ASSISTANT
Col. G. R. Weinbrenner

ASST. FOR MANAGEMENT
Maj. A. B. Holladay

DIRECTORATE OF SCIENCE & TECHNOLOGY PLANNING
Col. L. E. Ireland

DIRECTORATE OF SYSTEMS PLANNING
Col. F. A. Holm

DIRECTORATE OF AFSC RESOURCE PLANNING
Col. C. C. Lutman

DIRECTORATE OF ANALYSIS & LONG-RANGE PLANNING
Col. P. L. Huie

DIRECTORATE OF POLICY & CONCEPTS PLANNING
Col. R. F. Todd

DCS/Comptroller
Brig. Gen. W. E. Carter
ASSISTANT
Col. M. S. Benedict
EXECUTIVE
Lt. Col. P. R. Taylor

DIRECTORATE OF PROGRAMMING
Col. C. D. Waldecker

DIRECTORATE OF ACCOUNTING & FINANCE
Col. R. F. Amos

DIRECTORATE OF BUDGET
Col R B Powers

DIRECTORATE OF DATA SYSTEMS & STATISTICS
Lt Col H W. Roberts

DIRECTORATE OF COST ANALYSIS
Col. J. B. Henderson

DIRECTORATE OF STATUS ANALYSIS
Col J B Warren

DCS/Science & Technology
Col. B. W. Marschner
ASSISTANT
Mr. A. G. Wimer, Jr.
EXECUTIVE OFFICER
Capt. A. K. Horn

DIRECTORATE OF BIOASTRONAUTICS
Col. P. G. Keil

DIRECTORATE OF RESEARCH & TECHNOLOGY
Col. R. W. W. Booth

DCS/ Staff/Systems
Col. R. H. Cobb (acting)
ASSISTANT
Col. R. H. Cobb
EXECUTIVE OFFICER
Col. Q. J. Goss

ASST. FOR LIMITED WAR
Col. M. E. Marston

DIRECTORATE OF SYSTEMS POLICY
Col. J. S. Chandler

DIRECTORATE OF SYSTEMS TEST SUPPORT
Col. H. C. Swan

DIRECTORATE OF AERONAUTICAL SYSTEMS
Col. R. W. Soderberg

DIRECTORATE OF BALLISTIC MISSILES
Col. H K Higginbotham

DIRECTORATE OF RECONNAISSANCE
Col. A. E. Smith, Jr.

DIRECTORATE OF ADVANCED SYSTEMS
Col. S. W. Brewer

DIRECTORATE OF ELECTRONIC SYSTEMS
Col M E Kay

AEROSPACE MEDICAL DIV.
Maj. Gen. T. C. Bedwell, Jr.
Brooks AFB, Texas

AERONAUTICAL SYSTEMS DIV.
Maj. Gen. Charles H. Terhune, Jr.
Wright-Patterson AFB, Ohio

BALLISTIC SYSTEMS DIV.
Brig. Gen. Harry J. Sands, Jr.
Norton AFB, California

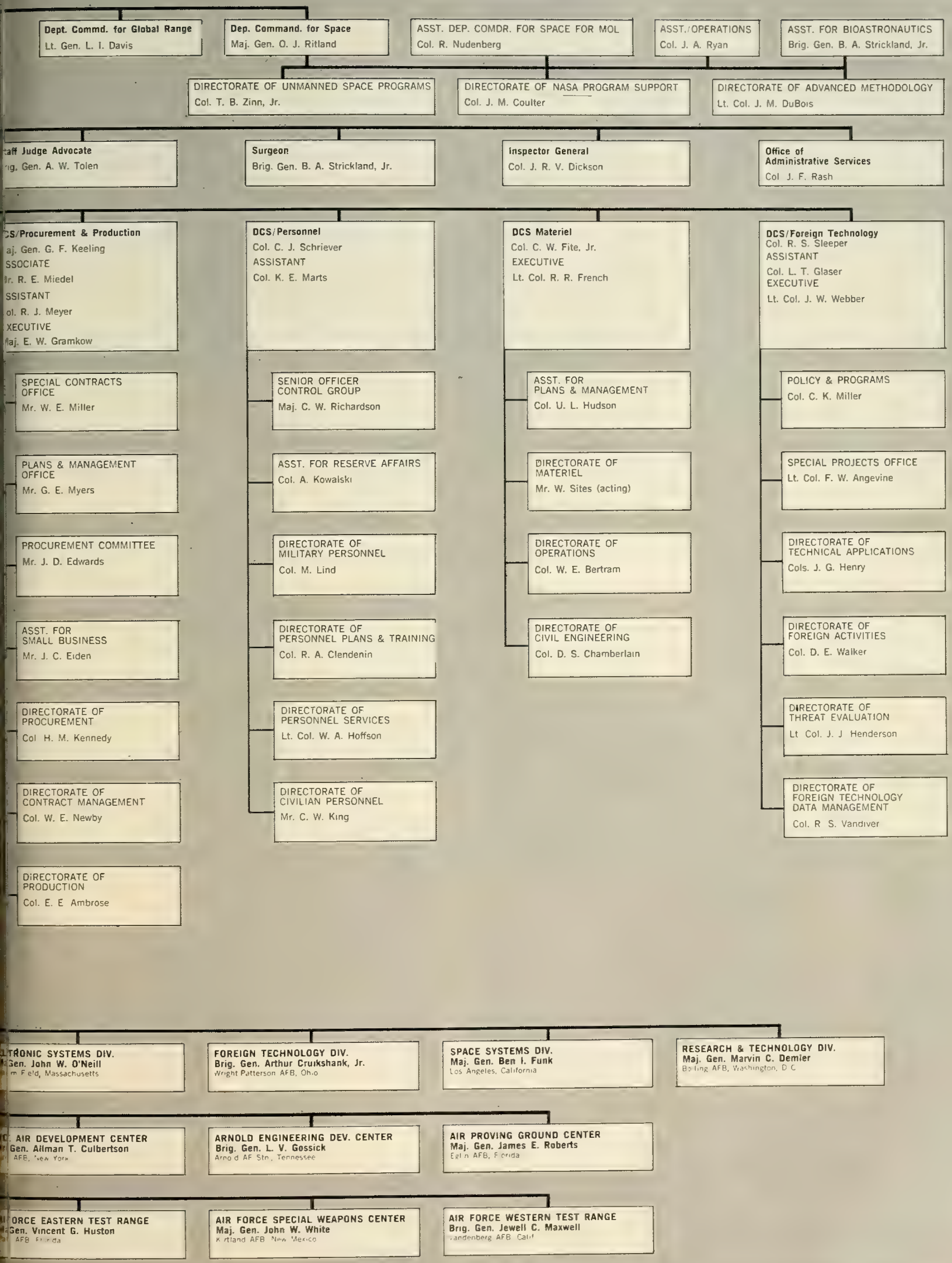
EASTERN CONTR. MGT. REGION
Col. William R. Large, Jr.
Olmstead AFB, Pennsylvania

CENTRAL CONTR. MGT. REGION
Col. H. G. MacDonald
Wright Patterson AFB, Ohio

WESTERN CONTR. MGT. REGION
Col. Fred L. Rennels
Mira Loma AF Stn California

AIR FORCE FLIGHT TEST CENTER
Maj. Gen. Irving L. Branch
Edwards AFB California

AIR FORCE MISSILE DEV. CENTER
Col. Ralph S. Garman
Holloman AFB New Mexi



Dept. Commd. for Global Range
Lt. Gen. L. I. Davis

Dep. Command. for Space
Maj. Gen. O. J. Ritland

ASST. DEP. COMDR. FOR SPACE FOR MOL
Col. R. Nudenberg

ASST./OPERATIONS
Col. J. A. Ryan

ASST. FOR BIOASTRONAUTICS
Brig. Gen. B. A. Strickland, Jr.

DIRECTORATE OF UNMANNED SPACE PROGRAMS
Col. T. B. Zinn, Jr.

DIRECTORATE OF NASA PROGRAM SUPPORT
Col. J. M. Coulter

DIRECTORATE OF ADVANCED METHODOLOGY
Lt. Col. J. M. DuBois

aff Judge Advocate
ig. Gen. A. W. Tolen

Surgeon
Brig. Gen. B. A. Strickland, Jr.

Inspector General
Col. J. R. V. Dickson

Office of
Administrative Services
Col J. F. Rash

S/Procurement & Production
aj. Gen. G. F. Keeling
SSOCIATE
r. R. E. Miedel
SSISTANT
ol. R. J. Meyer
XECUTIVE
aj. E. W. Gramkow

SPECIAL CONTRACTS OFFICE
Mr. W. E. Miller

PLANS & MANAGEMENT OFFICE
Mr. G. E. Myers

PROCUREMENT COMMITTEE
Mr. J. D. Edwards

ASST. FOR SMALL BUSINESS
Mr. J. C. Eiden

DIRECTORATE OF PROCUREMENT
Col H. M. Kennedy

DIRECTORATE OF CONTRACT MANAGEMENT
Col. W. E. Newby

DIRECTORATE OF PRODUCTION
Col. E. E Ambrose

DCS/Personnel
Col. C. J. Schriever
ASSISTANT
Col. K. E. Marts

SENIOR OFFICER CONTROL GROUP
Maj. C. W. Richardson

ASST. FOR RESERVE AFFAIRS
Col. A. Kowalski

DIRECTORATE OF MILITARY PERSONNEL
Col. M. Lind

DIRECTORATE OF PERSONNEL PLANS & TRAINING
Col. R. A. Clendenin

DIRECTORATE OF PERSONNEL SERVICES
Lt. Col. W. A. Hoffson

DIRECTORATE OF CIVILIAN PERSONNEL
Mr. C. W. King

DCS Materiel
Col. C. W. Fite, Jr.
EXECUTIVE
Lt. Col. R. R. French

ASST. FOR PLANS & MANAGEMENT
Col. U. L. Hudson

DIRECTORATE OF MATERIEL
Mr. W. Sites (acting)

DIRECTORATE OF OPERATIONS
Col. W. E. Bertram

DIRECTORATE OF CIVIL ENGINEERING
Col. D. S. Chamberlain

DCS/Foreign Technology
Col. R. S. Sleeper
ASSISTANT
Col. L. T. Glaser
EXECUTIVE
Lt. Col. J. W. Webber

POLICY & PROGRAMS
Col. C. K. Miller

SPECIAL PROJECTS OFFICE
Lt. Col. F. W. Angevine

DIRECTORATE OF TECHNICAL APPLICATIONS
Cols. J. G. Henry

DIRECTORATE OF FOREIGN ACTIVITIES
Col. D. E. Walker

DIRECTORATE OF THREAT EVALUATION
Lt Col. J. J Henderson

DIRECTORATE OF FOREIGN TECHNOLOGY DATA MANAGEMENT
Col. R S. Vandiver

TRONIC SYSTEMS DIV.
Gen. John W. O'Neill
m Field, Massachusetts

FOREIGN TECHNOLOGY DIV.
Brig. Gen. Arthur Cruikshank, Jr.
Wright Patterson AFB, Ohio

SPACE SYSTEMS DIV.
Maj. Gen. Ben I. Funk
Los Angeles, California

RESEARCH & TECHNOLOGY DIV.
Maj. Gen. Marvin C. Demler
Bolling AFB, Washington, D C

AIR DEVELOPMENT CENTER
Gen. Allman T. Culbertson
AFB, New York

ARNOLD ENGINEERING DEV. CENTER
Brig. Gen. L. V. Gossick
Arnold AF Stn., Tennessee

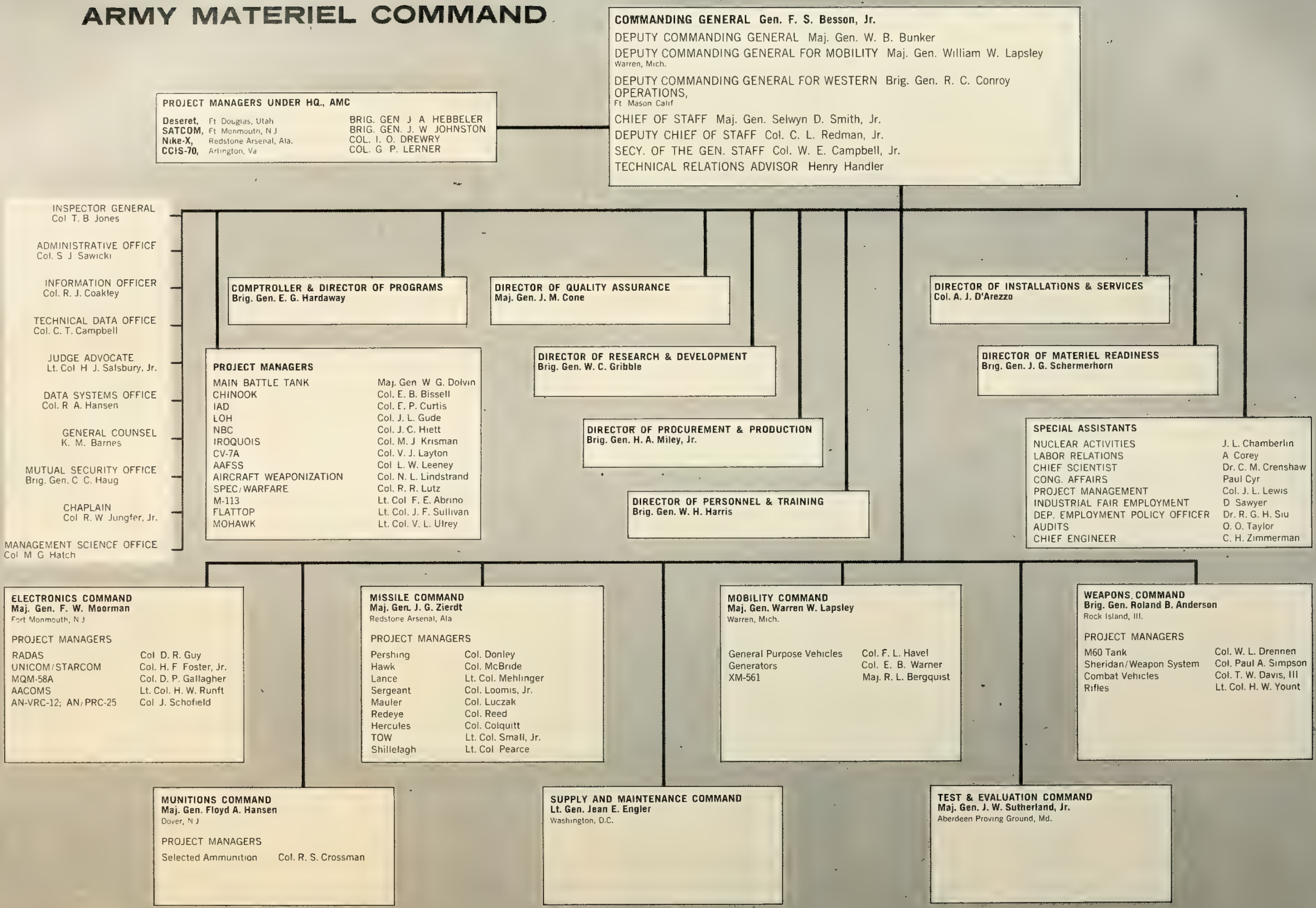
AIR PROVING GROUND CENTER
Maj. Gen. James E. Roberts
Eglin AFB, Florida

ORCE EASTERN TEST RANGE
Gen. Vincent G. Huston
AFB Florida

AIR FORCE SPECIAL WEAPONS CENTER
Maj. Gen. John W. White
Kirtland AFB New Mexico

AIR FORCE WESTERN TEST RANGE
Brig. Gen. Jewell C. Maxwell
Vandenberg AFB Calif

ARMY MATERIEL COMMAND



COMMANDING GENERAL Gen. F. S. Besson, Jr.
DEPUTY COMMANDING GENERAL Maj. Gen. W. B. Bunker
DEPUTY COMMANDING GENERAL FOR MOBILITY Maj. Gen. William W. Lapsley
Warren, Mich.
DEPUTY COMMANDING GENERAL FOR WESTERN OPERATIONS, Brig. Gen. R. C. Conroy
Ft Mason Calif
CHIEF OF STAFF Maj. Gen. Selwyn D. Smith, Jr.
DEPUTY CHIEF OF STAFF Col. C. L. Redman, Jr.
SECY. OF THE GEN. STAFF Col. W. E. Campbell, Jr.
TECHNICAL RELATIONS ADVISOR Henry Handler

PROJECT MANAGERS UNDER HQ., AMC

Deseret,	Ft Douglas, Utah	BRIG. GEN J A HEBBELER
SATCOM,	Ft Monmouth, N J	BRIG. GEN. J. W JOHNSTON
Nike-X,	Redstone Arsenal, Ala.	COL. I. O. DREWRY
CCIS-70,	Arlington, Va	COL. G P. LERNER

INSPECTOR GENERAL
Col T. B Jones

ADMINISTRATIVE OFFICE
Col. S J Sawicki

INFORMATION OFFICER
Col. R. J. Coakley

TECHNICAL DATA OFFICE
Col. C. T. Campbell

JUDGE ADVOCATE
Lt. Col H J. Salsbury, Jr.

DATA SYSTEMS OFFICE
Col. R A. Hansen

GENERAL COUNSEL
K. M. Barnes

MUTUAL SECURITY OFFICE
Brig. Gen. C C. Haug

CHAPLAIN
Col R. W Jungfer, Jr.

MANAGEMENT SCIENCE OFFICE
Col M G Hatch

COMPTROLLER & DIRECTOR OF PROGRAMS
Brig. Gen. E. G. Hardaway

PROJECT MANAGERS

MAIN BATTLE TANK	Maj. Gen W G. Dolvin
CHINOOK	Col. E. B. Bissell
IAD	Col. E. P. Curtis
LOH	Col. J. L. Gude
NBC	Col. J. C. Hiett
IROQUOIS	Col. M. J Krisman
CV-7A	Col. V. J. Layton
AAFSS	Col L. W. Leeney
AIRCRAFT WEAPONIZATION	Col. N. L. Lindstrand
SPEC/WARFARE	Col. R. R. Lutz
M-113	Lt. Col F. E. Abrino
FLATTOP	Lt. Col. J. F. Sullivan
MOHAWK	Lt. Col. V. L. Ulrey

DIRECTOR OF QUALITY ASSURANCE
Maj. Gen. J. M. Cone

DIRECTOR OF RESEARCH & DEVELOPMENT
Brig. Gen. W. C. Gribble

DIRECTOR OF PROCUREMENT & PRODUCTION
Brig. Gen. H. A. Miley, Jr.

DIRECTOR OF PERSONNEL & TRAINING
Brig. Gen. W. H. Harris

DIRECTOR OF INSTALLATIONS & SERVICES
Col. A. J. D'Arezzo

DIRECTOR OF MATERIEL READINESS
Brig. Gen. J. G. Schermerhorn

SPECIAL ASSISTANTS

NUCLEAR ACTIVITIES	J. L. Chamberlin
LABOR RELATIONS	A Corey
CHIEF SCIENTIST	Dr. C. M. Crenshaw
CONG. AFFAIRS	Paul Cyr
PROJECT MANAGEMENT	Col. J. L. Lewis
INDUSTRIAL FAIR EMPLOYMENT	D Sawyer
DEP. EMPLOYMENT POLICY OFFICER	Dr. R. G. H. Siu
AUDITS	O. O. Taylor
CHIEF ENGINEER	C. H. Zimmerman

ELECTRONICS COMMAND
Maj. Gen. F. W. Moorman
Fort Monmouth, N J

PROJECT MANAGERS

RADAS	Col D. R. Guy
UNICOM/STARCOM	Col. H. F Foster, Jr.
MQM-58A	Col. D. P. Gallagher
AACOMS	Lt. Col. H. W. Runft
AN-VRC-12; AN/PRC-25	Col J. Schofield

MISSILE COMMAND
Maj. Gen. J. G. Zierdt
Redstone Arsenal, Ala

PROJECT MANAGERS

Pershing	Col. Donley
Hawk	Col. McBride
Lance	Lt. Col. Mehlinger
Sergeant	Col. Loomis, Jr.
Mauler	Col. Luczak
Redeye	Col. Reed
Hercules	Col. Colquitt
TOW	Lt. Col. Small, Jr.
Shillelagh	Lt. Col Pearce

MOBILITY COMMAND
Maj. Gen. Warren W. Lapsley
Warren, Mich.

General Purpose Vehicles	Col. F. L. Havel
Generators	Col. E. B. Warner
XM-561	Maj. R. L. Bergquist

WEAPONS COMMAND
Brig. Gen. Roland B. Anderson
Rock Island, Ill.

PROJECT MANAGERS

M60 Tank	Col. W. L. Drennen
Sheridan/Weapon System	Col. Paul A. Simpson
Combat Vehicles	Col. T. W. Davis, III
Rifles	Lt. Col. H. W. Yount

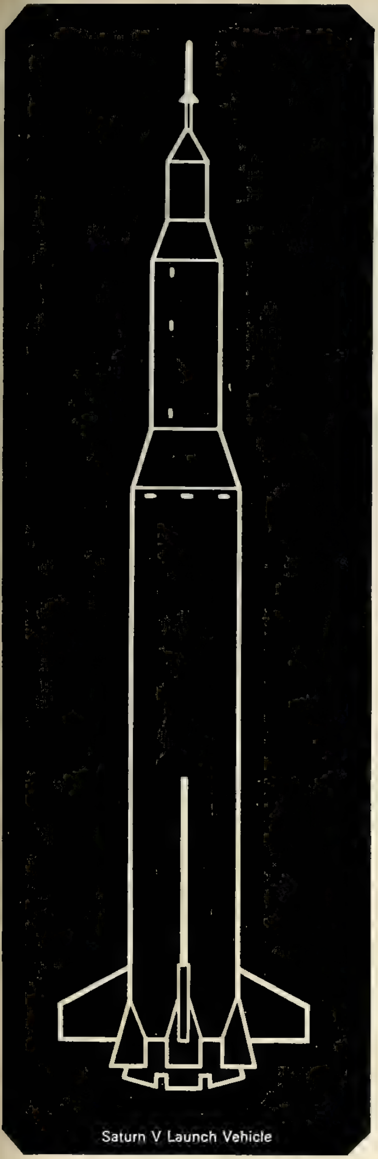
MUNITIONS COMMAND
Maj. Gen. Floyd A. Hansen
Dover, N J

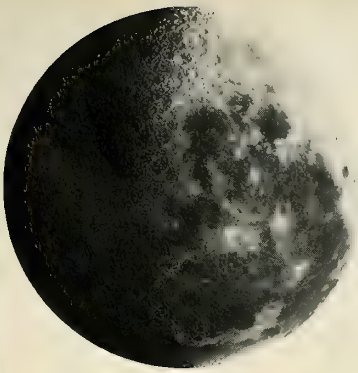
PROJECT MANAGERS

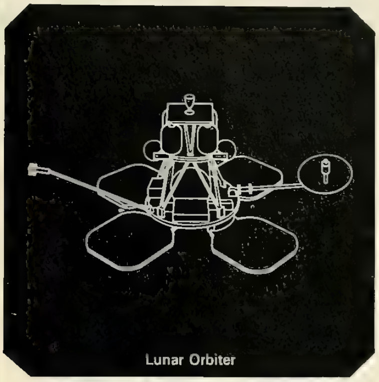
Selected Ammunition	Col. R. S. Crossman

SUPPLY AND MAINTENANCE COMMAND
Lt. Gen. Jean E. Engler
Washington, D.C.

TEST & EVALUATION COMMAND
Maj. Gen. J. W. Sutherland, Jr.
Aberdeen Proving Ground, Md.

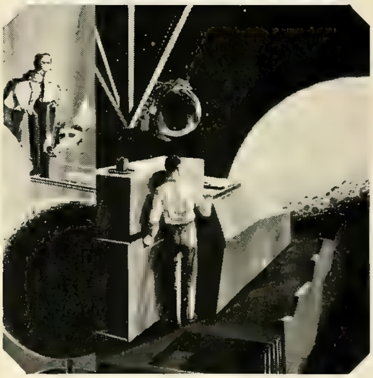

Saturn V Launch Vehicle




Lunar Orbiter

Minuteman ICBM

Space-Age Boeing Openings


Space Research

for Engineers and Scientists

The Boeing Company's Aero-Space Division, major contractor for the Saturn V launch vehicle, Minuteman ICBM and the lunar orbiter, has a number of challenging opportunities for graduate engineers and scientists. (See list in right-hand column.) Assignments, which vary with each Boeing facility, are at Cape Kennedy, Fla.; Huntsville, Ala.; New Orleans, La.; Seattle, Wash., and Vandenberg AFB, Calif.

Minimum requirements are a B.S. degree in an engineering or science discipline, plus applicable experience. Salaries are commensurate with your experience and education background. Travel and moving allowances are paid to newly hired personnel. Boeing is an equal opportunity employer.

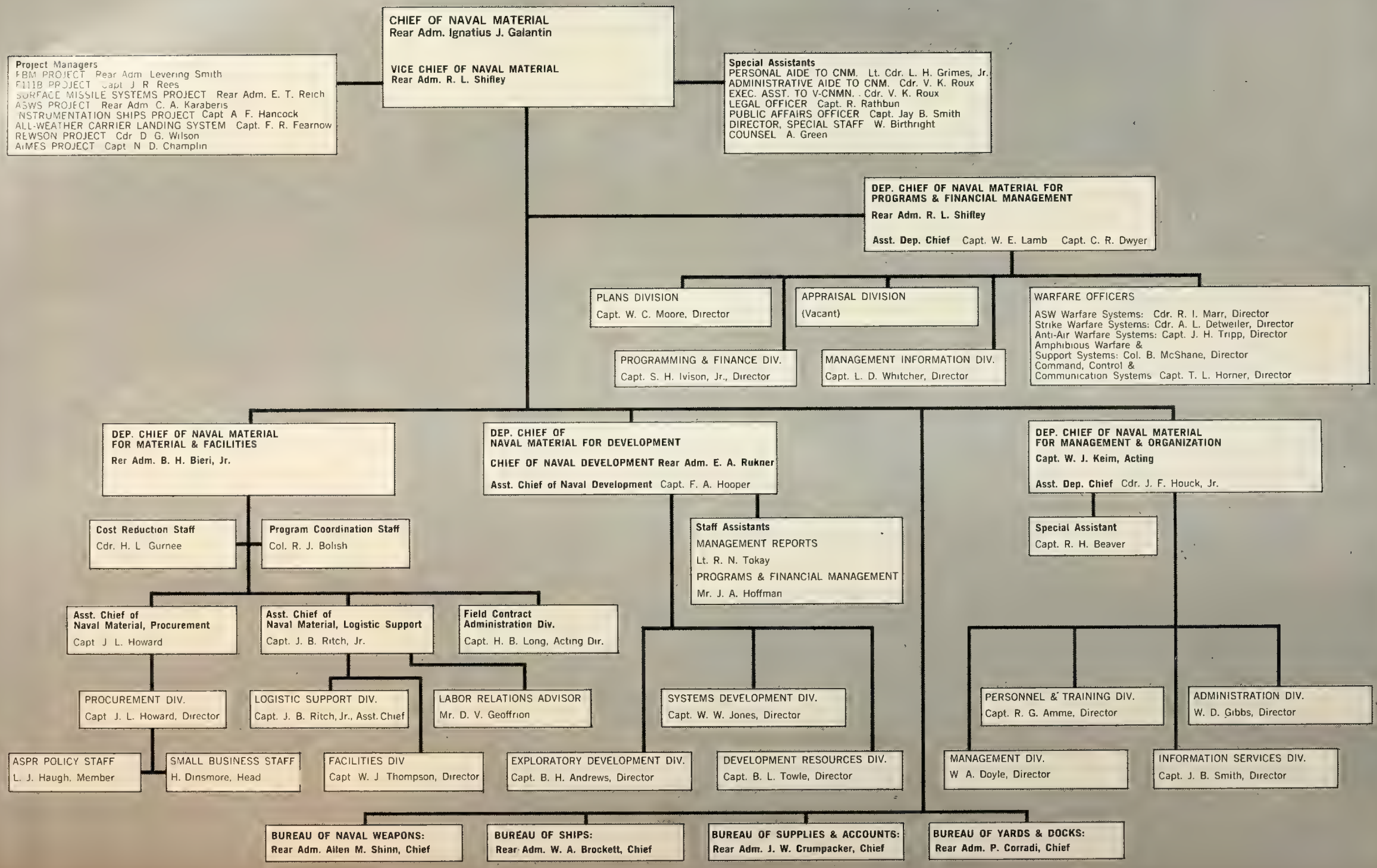
Send your resume today to the employment manager at the installation(s) you prefer: Mr. L. S. Bonsteel, Boeing Atlantic Test Center, P. O. Box 1698 - MSY, Cocoa Beach, Fla.; Mr. John Hall, Boeing Launch Systems Branch, P. O. Box 1680 - MSY, Huntsville, Ala.; Mr. L. Wendell Hays, Boeing Launch Systems Branch, P. O. Box 29100 - MSY, New Orleans, La. 70129; Mr. John H. Taylor, Boeing Pacific Test Center, P. O. Box 1626 - MSY, Vandenberg AFB, Calif., or Mr. Lawrence W. Blakeley, The Boeing Company, P. O. Box 3822 - MSY, Seattle, Wash. 98124.

Systems Engineering • Flight Technology • Telemetry Systems and Design • Electronics Technology • Instrumentation • Propulsion and Mechanical Systems • Scientific Computer Programming • Logistics Engineering • Aerospace Program Planning • Metallurgy • Test Engineering • Electrical/Electronic Design • Materials & Processes • Human Engineering • Cryogenics • Weights Engineering • Guidance & Control • Reliability • Service Engineering • Mechanical Design • Structures Analysis & Design • Computer & Logic Circuit Development • Industrial Engineering • Electronic/Electromechanical Parts Evaluation • Computer Systems Analysts

BOEING

Divisions: Airplane • Turbine • Vertol • **AERO-SPACE** • Also, Boeing Scientific Research Laboratories

OFFICE OF NAVAL MATERIAL


CHIEF OF NAVAL MATERIAL
Rear Adm. Ignatius J. Galantin
VICE CHIEF OF NAVAL MATERIAL
Rear Adm. R. L. Shifley
Project Managers
FBM PROJECT Rear Adm Levering Smith
F111B PROJECT Capt J R Rees
SURFACE MISSILE SYSTEMS PROJECT Rear Adm. E. T. Reich
ASWS PROJECT Rear Adm C. A. Karaberis
INSTRUMENTATION SHIPS PROJECT Capt A F. Hancock
ALL-WEATHER CARRIER LANDING SYSTEM Capt. F. R. Fearnow
REWSON PROJECT Cdr D G. Wilson
AIMES PROJECT Capt N D. Champlin
Special Assistants
PERSONAL AIDE TO CNM. Lt. Cdr. L. H. Grimes, Jr.
ADMINISTRATIVE AIDE TO CNM. Cdr. V. K. Roux
EXEC. ASST. TO V-CNMN. Cdr. V. K. Roux
LEGAL OFFICER Capt. R. Rathbun
PUBLIC AFFAIRS OFFICER Capt. Jay B. Smith
DIRECTOR, SPECIAL STAFF W. Birthright
COUNSEL A. Green
DEP. CHIEF OF NAVAL MATERIAL FOR PROGRAMS & FINANCIAL MANAGEMENT
Rear Adm. R. L. Shifley
Asst. Dep. Chief Capt. W. E. Lamb Capt. C. R. Dwyer
PLANS DIVISION
Capt. W. C. Moore, Director
APPRAISAL DIVISION
(Vacant)
WARFARE OFFICERS
ASW Warfare Systems: Cdr. R. I. Marr, Director
Strike Warfare Systems: Cdr. A. L. Detweiler, Director
Anti-Air Warfare Systems: Capt. J. H. Tripp, Director
Amphibious Warfare & Support Systems: Col. B. McShane, Director
Command, Control & Communication Systems Capt. T. L. Horner, Director
PROGRAMMING & FINANCE DIV.
Capt. S. H. Ivison, Jr., Director
MANAGEMENT INFORMATION DIV.
Capt. L. D. Whitcher, Director
DEP. CHIEF OF NAVAL MATERIAL FOR MATERIAL & FACILITIES
Rer Adm. B. H. Bieri, Jr.
DEP. CHIEF OF NAVAL MATERIAL FOR DEVELOPMENT
CHIEF OF NAVAL DEVELOPMENT Rear Adm. E. A. Rukner
Asst. Chief of Naval Development Capt. F. A. Hooper
DEP. CHIEF OF NAVAL MATERIAL FOR MANAGEMENT & ORGANIZATION
Capt. W. J. Keim, Acting
Asst. Dep. Chief Cdr. J. F. Houck, Jr.
Cost Reduction Staff
Cdr. H. L Gurnee
Program Coordination Staff
Col. R. J. Bolish
Staff Assistants
MANAGEMENT REPORTS
Lt. R. N. Tokay
PROGRAMS & FINANCIAL MANAGEMENT
Mr. J. A. Hoffman
Special Assistant
Capt. R. H. Beaver
Asst. Chief of Naval Material, Procurement
Capt J L. Howard
Asst. Chief of Naval Material, Logistic Support
Capt. J. B. Ritch, Jr.
Field Contract Administration Div.
Capt. H. B. Long, Acting Dir.
PROCUREMENT DIV.
Capt J. L. Howard, Director
LOGISTIC SUPPORT DIV.
Capt. J. B. Ritch, Jr., Asst. Chief
LABOR RELATIONS ADVISOR
Mr. D. V. Geoffrion
SYSTEMS DEVELOPMENT DIV.
Capt. W. W. Jones, Director
PERSONNEL & TRAINING DIV.
Capt. R. G. Amme, Director
ADMINISTRATION DIV.
W. D. Gibbs, Director
ASPR POLICY STAFF
L. J. Haugh, Member
SMALL BUSINESS STAFF
H. Dinsmore, Head
FACILITIES DIV
Capt W. J Thompson, Director
EXPLORATORY DEVELOPMENT DIV.
Capt. B. H. Andrews, Director
DEVELOPMENT RESOURCES DIV.
Capt. B. L. Towle, Director
MANAGEMENT DIV.
W A. Doyle, Director
INFORMATION SERVICES DIV.
Capt. J. B. Smith, Director
BUREAU OF NAVAL WEAPONS:
Rear Adm. Allen M. Shinn, Chief
BUREAU OF SHIPS:
Rear Adm. W. A. Brockett, Chief
BUREAU OF SUPPLIES & ACCOUNTS:
Rear Adm. J. W. Crumpacker, Chief
BUREAU OF YARDS & DOCKS:
Rear Adm. P. Corradi, Chief

HOW TO GET MORE INFORMATION

about products, capabilities, and literature in this issue

- Circle the appropriate numbers on the card.
- Fill out the card completely . . . title and company are a MUST.
- Tear out the card and mail (we pay the postage).

NAME____________________

TITLE / POSITION____________________

COMPANY____________________

BUSINESS ADDRESS____________________

CITY____________________STATE______ ZIP # ________

missiles and rockets march 29, 1965

CIRCLE NUMBERS BELOW FOR INFORMATION ON PRODUCTS, LITERATURE OR ADVERTISEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125
126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249
250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274
275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299

please send me a subscription form for / missiles and rockets ☐

BUSINESS REPLY MAIL

POSTAGE WILL BE PAID BY

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY
P.O. BOX 7653
PHILADELPHIA 1, PA.

HOW TO GET MORE INFORMATION

about products, capabilities, and literature in this issue

- Circle the appropriate numbers on the card.
- Fill out the card completely . . . title and company are a MUST.
- Tear out the card and mail (we pay the postage).

NAME____________________

TITLE / POSITION____________________

COMPANY____________________

BUSINESS ADDRESS____________________

CITY__________ **STATE**_____ **ZIP #**_____

missiles and rockets march 29, 1965

CIRCLE NUMBERS BELOW FOR INFORMATION ON PRODUCTS, LITERATURE OR ADVERTISEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125
126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249
250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274
275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299

please send me a subscription form for / missiles and rockets ☐

First Class
Permit No.
25357
Philadelphia, Pa.

BUSINESS REPLY MAIL

POSTAGE WILL BE PAID BY

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY
P.O. BOX 7653
PHILADELPHIA 1, PA.

WHO...WHAT...WHERE...

in the Missile/Space Industries!

WORLD SPACE DIRECTORY
SECTION B-1 MAJOR MISSILE/SPACE MANUFACTURERS
SECTION B-2 COMPONENT MISSILE/SPACE MANUFACTURERS
SECTION D MISSILE/SPACE CONSULTANTS & SPECIAL SERVICES
EXECUTIVE BRANCH
FRANCE

Spring 1965 Edition

17,000 KEY PERSONNEL IN 4,250 COMPANIES
NAMES—ADDRESSES—PRODUCTS—SERVICES
—MISSILE/SPACE REFERENCE MATERIAL—

No matter what you're looking for in missile/space, you'll find your first lead in the WORLD SPACE DIRECTORY. Whether you're interested in reaching key industry or defense executives, bidding on a government contract, planning research or production programs, sizing up competition, or looking for a job . . . the WORLD SPACE DIRECTORY is your primary source of information.

RETURN THIS COUPON

WORLD SPACE DIRECTORY
New Edition
Spring 1965
50% Revised

$12.50 per copy—U.S., Possessions, Canada; $13.50 all other countries

☐ Copies ☐ Bill me ☐ Bill Company

Name
Title/Position
Street **City** **State** **Zip #**
Company Name
Division

1001 Vermont Avenue, N.W., Washington, D.C. 20005

MELPAR, INC.
M

HOW LONG IS TWENTY YEARS?

Not long, for some companies; but for an organization specializing in modern electronic research and development, it is as old as the industry itself. Our first twenty-year man receives a pin like the one above this year.

Melpar has helped pioneer many of the technological breakthroughs of the past twenty years—what will the advances be in the next twenty years? We think we know what a few will be. We're working on them now. If you are a scientist or engineer interested and capable of working ahead of the pack, we want to talk to you now.

Wide diversification at Melpar in more than 110 major contracts offers many challenging assignments to qualified scientists and engineers.

We have immediate requirements for:

PHYSICISTS

for developmental work in the use of infra-red detectors and optics and their application for chemical analysis. Additional requirements in all phases of thin film microcircuitry.

ELECTRONIC ENGINEERS

to work in Pattern Recognition, Network Synthesis, Random Noise Theory, Speech Synthesis, Data Retrievel, Microwave Systems Receiver Design, Circuit Design, and Machine Intelligence.

Write Clarence Endsley, Professional Placement

MELPAR INC
A SUBSIDIARY OF WESTINGHOUSE AIR BRAKE COMPANY
3493 Arlington Boulevard, Falls Church, Virginia
An equal opportunity employer.

SPACE SCIENCES • SPECIAL PURPOSE DATA PROCESSING • ELECTRONIC WARFARE SYSTEMS • ORDNANCE DEVICES • SIMULATION AND TRAINING
SPECIAL DETECTION SYSTEMS, BIOLOGICAL AND CHEMICAL • COMMUNICATIONS • LIFE SCIENCES • MICROELECTRONICS • TEST AND EVALUATION

Circle No. 46 on Subscriber Service Card

Guide to Key Procurement Contacts

ARMY

U.S. ARMY MATERIEL COMMAND

Electronics Command

Fort Monmouth, New Jersey

Maj. Gen. F. W. Moorman
Tel.: 523-9000, area code 201

Interests: Integrated commodity management of communications, communications security, electronic warfare, aviation electronics, combat surveillance, photographic and microfilming, identification—friend or foe (radar) systems; automatic data processing, radar (excluding that used in fire control and fire coordination of air defense systems assigned to another command for management), meteorological and electronic radiological detection materiel; electric power generation equipment (as assigned by Headquarters, AMC); related test equipment; and electronic parts and materials common to electronic materiel throughout the Army. Basic and applied research concerning assigned materiel development.

Missile Command

Redstone Arsenal, Alabama

Maj. Gen. J. G. Zierdt
Tel.: 877-1100, area code 205

Interests: Integrated commodity management of free rockets, guided missiles, ballistic missiles, target missiles, air defense missile fire coordination equipment, related special-purpose and multi-system test equipment, missile launching and ground equipment, missile fire control equipment and other associated equipment. Basic and applied research concerning assigned materiel development.

Mobility Command

Warren, Michigan

Maj. Gen. Alden K. Sibley
Tel.: 536-5000, area code 313

Interests: Integrated commodity management of aeronautical and air delivery equipment, tactical wheeled and general-purpose vehicles, other surface transportation equipment, mapping and geodosy equipment for the field armies, electric power generation equipment (as assigned by Headquarters, AMC). Construction and services equipment. Barrier equipment (including mine warfare and demolitions equipment), bridging and stream-crossing equipment, night vision equipment, petroleum handling and dispensing equipment and general support equipment and supplies. Basic and applied research concerning assigned materiel development.

Munitions Command

Dover, New Jersey

Maj. Gen. Floyd A. Hansen
Tel.: FO 1-2100, area code 201

Interests: Integrated commodity management of nuclear and non-nuclear ammunition, rocket and missile warhead sections; chemical, biological and radiological materiel; pyrotechnics and propellant-actuated devices. Basic and applied research concerning assigned materiel development.

Supply & Maintenance Command

Washington, D.C.

Lt. Gen. Jean E. Engler
Tel.: OX 6-8624, area code 202

Interests: Army-wide technical control for distribution and maintenance and for petroleum logistics assigned to the Army for all military services and other customers. AMC-wide operational control for: integrated inventory management and control of all secondary items; cataloging; processing authorization documents for all items; AMC division of Army stock fund; policy, systems and procedures for supply control, stock control, distribution, maintenance, land and air transportation, allocation of administrative-use transport, and property disposal; interservice support (including DSA) and agreements therefor; and support of military planning for all items except PEMA major items, commodity item responsibility for assigned DSA items.

Test & Evaluation Command

Aberdeen Proving Ground, Maryland

Maj. Gen. J. W. Sutherland, Jr.
Tel.: 272-4000, area code 301

Interests: Engineering and service tests and evaluations; support engineer design, production and post-production tests; and participation in troop test planning.

Weapons Command

Rock Island, Illinois

Brig. Gen. Roland B. Anderson
Tel.: 788-8411, area code 309

Interests: Integrated commodity management of weapons and combat vehicles, and fire control equipment. Basic and applied research concerning assigned materiel development.

AIR FORCE

AIR FORCE SYSTEMS COMMAND

Headquarters, AFSC

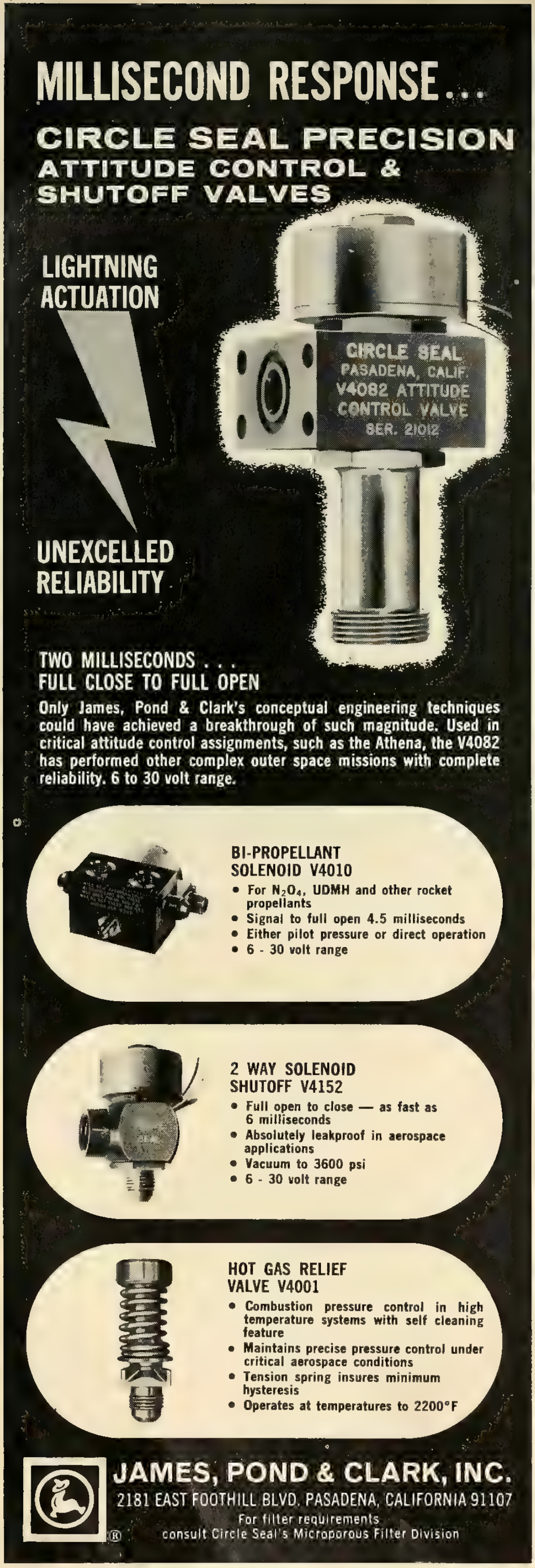
Andrews AFB, Washington, D.C. 20331
Base tel. number: 981-9111, area code 301

CONTRACTOR RELATIONS OFFICER: William S. Catts
Mail Office Symbol: SCKPP
Extension: 6331, 3288

UNSOLICITED PROPOSALS: Seymour Milnovsky
Mail Office Symbol: SCKPP
Extension: 6331, 3288

SOURCE SPECIALIST: Robert F. Warren
(Bolling AFB, Washington, D.C. 20332)
Mail Office Symbol: SCKPP-3
Tel.: JO 2-9000, extension: 4102, 4006

SMALL BUSINESS EXECUTIVE: John C. Eiden
Mail Office Symbol: SCK-4
Extension: 6107, 6115



MILLISECOND RESPONSE...

CIRCLE SEAL PRECISION ATTITUDE CONTROL & SHUTOFF VALVES

LIGHTNING ACTUATION

UNEXCELLED RELIABILITY

CIRCLE SEAL
PASADENA, CALIF.
V4082 ATTITUDE
CONTROL VALVE
SER. 21012

TWO MILLISECONDS . . .
FULL CLOSE TO FULL OPEN

Only James, Pond & Clark's conceptual engineering techniques could have achieved a breakthrough of such magnitude. Used in critical attitude control assignments, such as the Athena, the V4082 has performed other complex outer space missions with complete reliability. 6 to 30 volt range.

BI-PROPELLANT
SOLENOID V4010

- For N_2O_4, UDMH and other rocket propellants
- Signal to full open 4.5 milliseconds
- Either pilot pressure or direct operation
- 6 - 30 volt range

2 WAY SOLENOID
SHUTOFF V4152

- Full open to close — as fast as 6 milliseconds
- Absolutely leakproof in aerospace applications
- Vacuum to 3600 psi
- 6 - 30 volt range

HOT GAS RELIEF
VALVE V4001

- Combustion pressure control in high temperature systems with self cleaning feature
- Maintains precise pressure control under critical aerospace conditions
- Tension spring insures minimum hysteresis
- Operates at temperatures to 2200°F

JAMES, POND & CLARK, INC.
2181 EAST FOOTHILL BLVD. PASADENA, CALIFORNIA 91107
For filter requirements
consult Circle Seal's Microporous Filter Division

Electronic Systems Division

L. G. Hanscom Field
Bedford, Massachusetts 01730
Base tel. number: 274-6100, area code 617

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:

John Condon, chief
Mail Office Symbol: ESKB
Extension: 2244
Assistant: William A. Cabral

Interests: Complete acquisition program for electronic, electromagnetic information and communications systems and equipment.

Aeronautical Systems Division

Wright-Patterson AFB, Ohio 45433
Base tel. number: 253-7111, area code 513

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:

George Rattenbury, chief
Mail Office Symbol: ASKS
Extension: 23222

Interests: Complete development and acquisition program for aeronautical systems and their components and related Government-Furnished Aerospace Equipment (GFAE) including but not limited to aircraft engines, aircraft wheels and brakes, airborne communication systems, aircraft bombing and navigation systems, aircraft instruments; Department of Defense central procurement responsibility for ground and aerial cameras, photographic processing equipment.

Systems Engineering Group

Research & Technology Division
Wright-Patterson AFB, Ohio, 45433
Base tel. number: 253-7111, area code 513

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:

Lawrence L. Grier, chief
Mail Office Symbol: SEKA
Extension: 26246, 38125

Interests: Exploratory and advanced development programs in air-breathing, electric and advanced propulsion, fuels and lubricants, flight vehicle power, site support, electronic components, optronics and photo material, inertial components, vehicle electromagnetic environment, aerospace vehicle applications such as reconnaissance, navigation and guidance, electronic warfare, materials sciences, metals and ceramics, non-metallic materials, manufacturing technology and materials application, flight vehicle dynamics, performance, control, launching, alighting, and structures, crew station, environment control, and escape, aerodynamic and decelerators. Basic and applied research in bioastronautics in human engineering, training, environmental stress criteria and life support. Basic research in selected areas of physical and mathematical science.

Aerospace Medical Division

Brooks AFB, Texas 78200
Base tel. number: 532-8811, area code 512

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:

Mildred Gibbs, chief
Mail Office Symbol: AMKS
Extension: 6227

Interests: Life sciences, human factors, aerospace medicine, biosciences, biomedicine, behavioral sciences, space medicine, biotechnology, human engineering, human resources, aviation medicine and space biology.

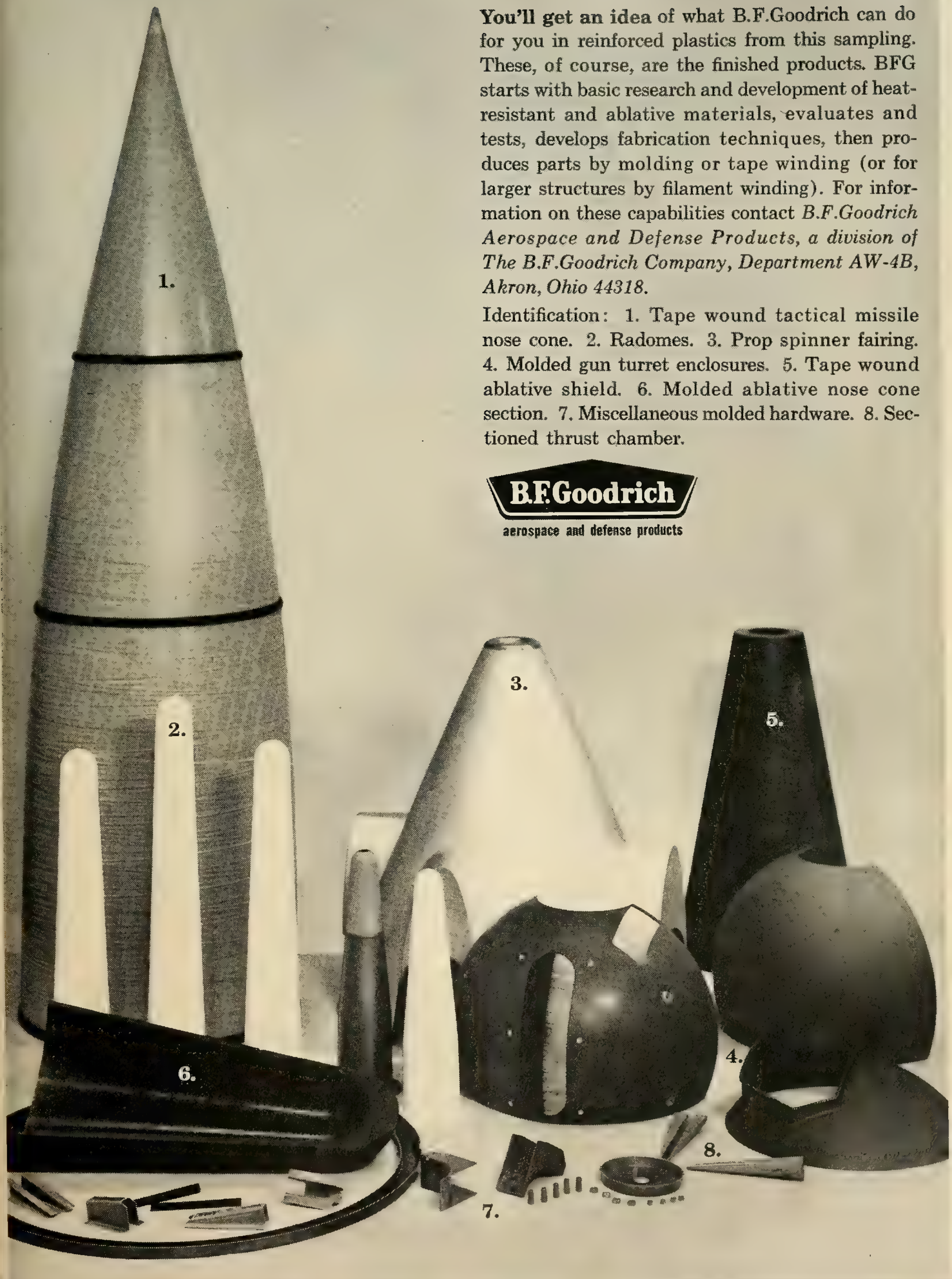
Space Systems Division

AF Unit Post Office, Los Angeles, Calif. 90045
Base tel. number: 670-1444, area code 213

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:

Roy A. Watkins, chief
Mail Office Symbol: SSKB
Extension: 32855

Interests: Acquisition of space vehicle systems and their components.



You'll get an idea of what B.F.Goodrich can do for you in reinforced plastics from this sampling. These, of course, are the finished products. BFG starts with basic research and development of heat-resistant and ablative materials, evaluates and tests, develops fabrication techniques, then produces parts by molding or tape winding (or for larger structures by filament winding). For information on these capabilities contact *B.F.Goodrich Aerospace and Defense Products, a division of The B.F.Goodrich Company, Department AW-4B, Akron, Ohio 44318.*

Identification: 1. Tape wound tactical missile nose cone. 2. Radomes. 3. Prop spinner fairing. 4. Molded gun turret enclosures. 5. Tape wound ablative shield. 6. Molded ablative nose cone section. 7. Miscellaneous molded hardware. 8. Sectioned thrust chamber.

B.F.Goodrich
aerospace and defense products

Circle No. 44 on Subscriber Service Card

.09
.08
.07
.06
.05
.04
.03
.02
.01
SUCCESS!

POSEIDON!

When designing missile hardware that must withstand extremely high temperatures ... whether rocket nozzle inserts, nose cones, leading edges, or hot gas valves . . . be sure to measure your requirements against the proven capabilities of tungsten and molybdenum.

Pure tungsten and molybdenum from General Electric have played key roles in the success of the Minuteman and Polaris and can make major contributions to the success of your design. The nozzle inserts in all stages of Minuteman II are machined from pure tungsten forgings.

Excellent resistance to erosion, corrosion, and thermal fracture are primary reasons for the use of tungsten nozzle inserts. Process development work by the forging industry has significantly lowered the ductile-brittle transition temperature of tungsten forgings—greatly improving resistance to thermal shock.

Forged tungsten is a tested and proven material. Thousands of intricate parts have been machined from it to close dimensional tolerances. The mirror finish now possible on tungsten parts is only one indication of the tremendous improvements that have been made in machining techniques.

For more information on tungsten or molybdenum, write or call: General Electric Co., Lamp Metals and Components Dept., 21800 Tungsten Rd., Cleveland, Ohio 44117. Tel: (216) 266-3145.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle No. 60 on Subscriber Service Card

Ballistic Systems Division
Norton AFB, California 95960
Base tel. number: 889-4411, area code 714

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:
L. R. McGary, chief
Mail Office Symbol: BSKB
Extension: 8553
Assistant: Mel Stone

Interests: Acquisition of ballistic missile systems and their components and activation of designated ballistic missile sites.

Air Force Flight Test Center
Edwards AFB, California 93523
Base tel. number: 258-2111, area code 805

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:
J. A. Beucherie, chief
Mail Office Symbol: FTMKB
Extension: 20121

CONTRACTOR RELATIONS OFFICER: Ruth Davis
Extension: 24151

Interests: Testing of new aircraft systems, research aircraft, aircraft components, flight test instrumentation, rocket propulsion and parachutes.

Air Force Special Weapons Center
Kirtland AFB, New Mexico 87117
Base tel. number: 247-1711, area code 505

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:
M. H. Nickerson, chief
Mail Office Symbol: SWMKB
Extension: 2917
Assistant: Clarice D. Corcoran

Interests: Testing and engineering in the field of nuclear weapons and associated equipment. Specific engineering interests include: telemetry, instrumentation; weapons/aircraft flight characteristics; high-speed camera techniques. Provides air support to the Atomic Energy Commission in the conduct of live nuclear tests in the Zone of Interior and in preparation for the Air Force air support role in overseas testing.

Air Force Weapons Laboratory
Kirtland AFB, New Mexico 87117
Base tel. number: 247-1711, area code 505

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:
M. H. Nickerson, chief
Mail Office Symbol: SWMKB
Extension: 2917
Assistant: Clarice D. Corcoran

Interests: Research in the areas of weapons effects, kill mechanisms, radiation hazards and delivery techniques. Development and evaluation programs for advanced non-conventional weapon and nuclear power systems integration, components, training devices, suspension and release and ground handling equipment.

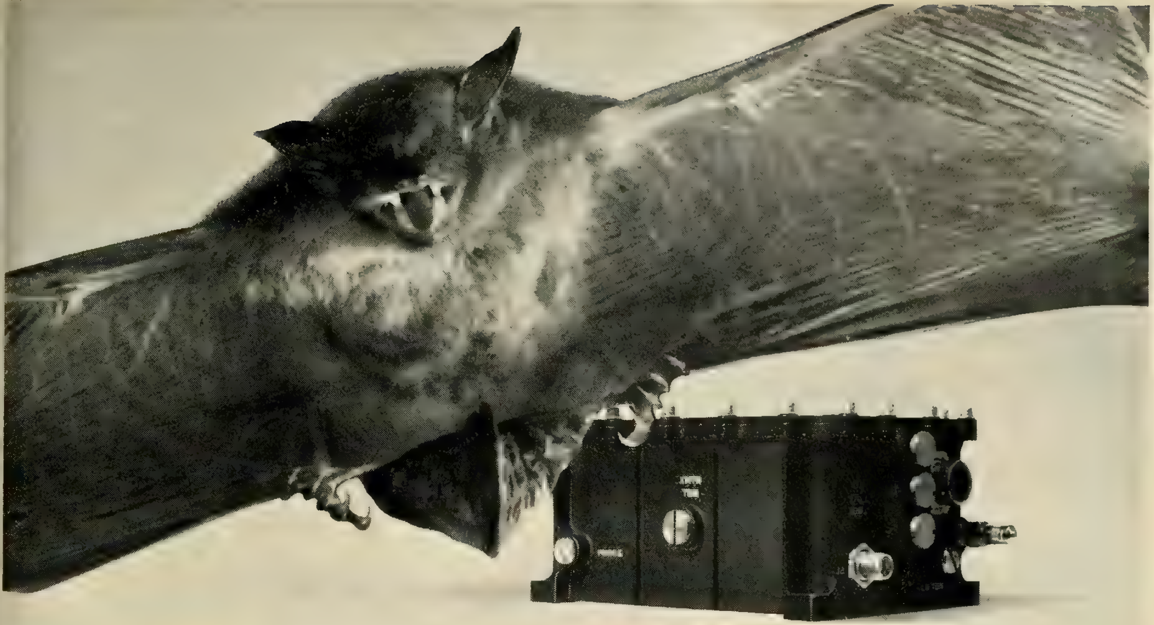
Air Force Eastern Test Range
Patrick AFB, Florida 32922
Base tel. number: 494-7545, area code 305

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:
George E. Gogel, chief
Mail Office Symbol: ETMKB
Extension: 7545

Interests: Test range instrumentation involving radar, trajectory computers and recorders, tracking and target analysis, wire communications, radio, communications, programming timing and firing systems, telemetry receiving data storage, data separation and presentation, optics and telemetry, data reduction.

Rome Air Development Center
Griffiss AFB, New York 13442
Base tel. number: 336-3200, area code 315

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:
John Vella, chief
Mail Office Symbol: EMKS
Extension: 5220
Assistant: R. Sykes



Bats will never replace our radar transponders!

Nature-lovers are often quick to point out that bats have the most efficient radar-type system known. Man, they say, can't approach it. With their tiny echolocation systems, bats emit high-frequency vocal signals that can detect an insect up to seven feet away...even in total darkness. The bat can lock on to a course that quickly culminates in impact and consumption.

This, admittedly, is remarkable. But Motorola radar transponders are required to send and receive reliable signals over vast distances—so they have been selected (in preference to bats...and even some very good man-made units) for use on major aerospace programs, such as Saturn... Pershing...Centaur...Apollo...Asset...Hound-dog...X-15...Gemini...Agena...Improved Delta to name a few. They are also range-qualified at WSMR, AMR, Eglin, and Edwards AFB.

Some of our off-the-shelf transponders on current programs include:

SST-135C (shown above): a new, general-purpose, solid-state, microminiaturized superheterodyne C-band transponder designed to full NASA quality and workmanship specs. High-component-density welded modules meet performance requirements for solid or liquid fuel rockets, missiles, and spacecraft. Qualified for Saturn, the SST-135C has 700 watts output, —65 dbm sensitivity, 0.05 μsec delay stability, weighs 5.5 pounds.

AN/DPN-66: 800 watts output, —70 dbm sensitivity, 0.05 μsec delay stability, 0.75 amp standby power drain.

SST-131: solid-state, microminiature, superheterodyne C-band transponder. 400 watts output, 3 pounds max.

SST-133X: general-purpose X-band transponder for use on drones, aircraft, and high-thrust launch vehicles. Volume: 44 cubic inches. Can be interchanged with our SST-131 C-band unit without modifying missile mounting configuration.

We can modify existing equipment, or produce new custom designs for you in short order. Incidentally, we lead the field in CW transponders, too. For example, the units which have so faithfully responded on Mariner and Ranger space missions were built by Motorola, in cooperation with NASA/JPL.

MOTOROLA

An equal opportunity employer.

Military Electronics Division

SCOTTSDALE, ARIZONA • CHICAGO 51, ILLINOIS

Attach coupon to your letterhead, and mention your transponder requirements.

For descriptive literature, check and mail to Dept. 1007, Motorola Military Electronics Div., 8201 E. McDowell Rd., Scottsdale, Arizona

- ☐ "Family Tree" specs on our complete line of transponders
- ☐ Nomograms—A guide to Transponder Selection
- ☐ Radar Systems Capabilities Brochure, and pamphlet, "Bits about Bats"

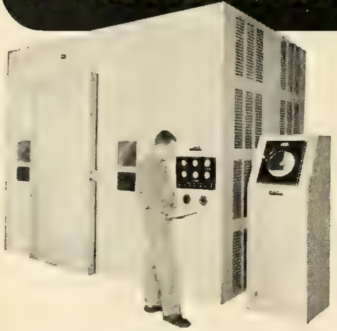
Circle No. 47 on Subscriber Service Card

TO SIMULATE SOLAR RADIATION

To test satellites and their components in the conditions of outer space, GENARCO Solar Radiation Simulators have been chosen by Bell Telephone, Bendix, General Dynamics, G.E., Grumman, J.P.L., Lincoln Lab., N.A.S.A. Space General, etc. Complete Genarco Simulators with carbon arc lamps as sources of radiation and several types of optical systems are available to meet your special requirements. Ask for illustrated literature:

GENARCO, INC.
97-04 Sutphin Blvd.
Jamaica 35, N.Y.
or call us to
discuss your problem:
Solar Simulators Division,
PHONE Code 212 658 5850

Circle No. 57 on Subscriber Service Card



WEBBER
Environmental Chambers

- **TEMPERATURE**
  Any temperature from —225° F. to +1000° F.
- **ALTITUDE**
  Any altitude simulated from 0 to 500,000 ft.
- **HUMIDITY**
  Relative humidity range standard and special

Thanks to six exclusive patented features, Webber offers more BTU's per hp, better performance, and greater reliability. Ask for a quotation . . . or for a representative to help with your problem.

Ask for This New Webber Brochure!
It's one of the most helpful ever published for buyers of environmental chambers.

WEBBER MANUFACTURING CO., INC.
P. O. Box 217 • Indianapolis, Ind. 46206 • Phone Area 317: 632-1378

Circle No. 58 on Subscriber Service Card

Interests: Surveillance, electronic intelligence, communications, computer and data processing techniques, textua data processing, intelligence extraction from aerial reconnaissance, data presentation, high-power electromagnetic generators, receivers, transmission line components, microelectronics applications, reliability and maintainability, survivability, propagation, vulnerability reduction, electronic countermeasures and electromagnetic weapons.

Air Proving Ground Center
Eglin AFB, Florida 32542
Base tel. number: EG 67-2843, area code 305

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:
J. V. Leftwich, chief
Mail Office Symbol: PGMKS
Assistant: Dorothy Anderson

Interests: Research, development, test and evaluation of guns and other aircraft weapons, ammunition, rockets, bombs and fire control components and systems.

Air Force Missile Development Center
Holloman AFB, New Mexico 88300
Base tel. number: 473-6511, area code 505

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:
D. P. Hathcock, chief
Mail Office Symbol: MDMKB
Extension: 46861

Interests: Guided missiles, conduct of research and development of guided subsystems and components. R&D in the field of human factors, including biodynamics and space biology. Execute Air Force responsibilities incident to the operation of the proving ground, including operation of special instrumentation in direct support of the center mission.

Arnold Engineering Development Center
Arnold Air Force Station, Tennessee 37706
Base tel. number: 455 2611, area code 615

CONTRACTOR RELATIONS, SOURCES & SMALL BUSINESS:
Joseph Moriarty, chief
Mail Office Symbol: AEK
Extension: 509

Interests: Aerodynamics, research and development of powerplants related to operation and tests of air-breathing propulsion systems, i.e., turbojet, ramjet and turboprop. Problems associated with high-temperature materials and unique mechanical, electrical and thermodynamic problems all related to the construction of large and complex engine test facilities and wind tunnels involving heavy construction of complicated machinery and associated ducting.

NAVY

BUREAU OF NAVAL WEAPONS

WASHINGTON, D.C.

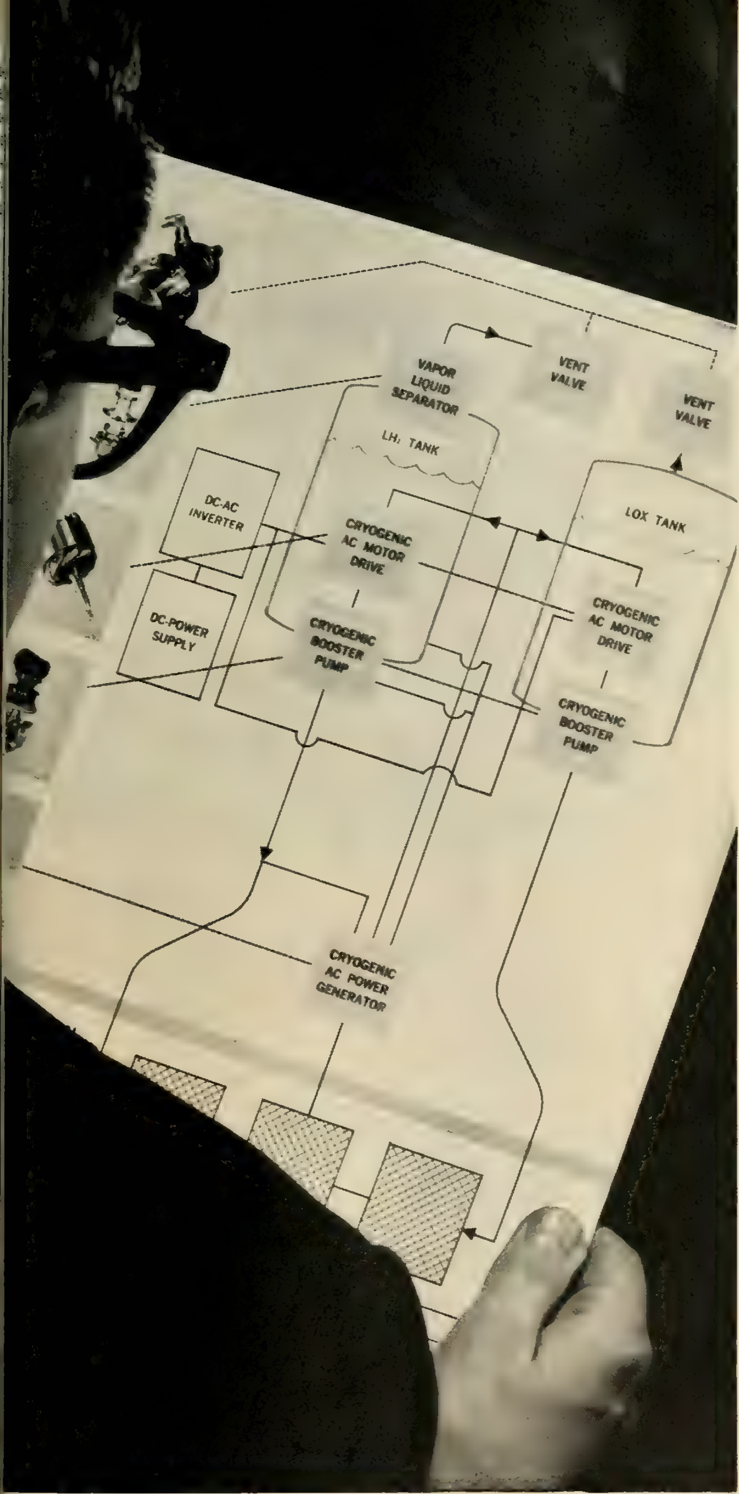
Purchase Officer:
Capt. G. H. Cook
1605 Munitions Building
Tel.: OX 6-2905

Airframes Division:
R. S. Young, director
1610 Munitions Building
Tel.: OX 6-3568

Components & Underwater Systems Division:
J. A. Ross, director
1606 Munitions Building
Tel.: OX 6-4510

Missiles Systems Division:
J. W. Frankl, director
1608 Munitions Building
Tel.: OX 6-2718

Contract Adjustment Division:
J. J. Mulligan, director
1633 Munitions Building
Tel.: OX 6-5119


VAPOR LIQUID SEPARATOR
VENT VALVE
VENT VALVE
LH₂ TANK
LOX TANK
DC-AC INVERTER
CRYOGENIC AC MOTOR DRIVE
DC-POWER SUPPLY
CRYOGENIC BOOSTER PUMP
CRYOGENIC AC MOTOR DRIVE
CRYOGENIC BOOSTER PUMP
CRYOGENIC AC POWER GENERATOR

"MASTER PLAN" for cryogenic propellant handling

PESCO PROPELLANT PUMPING SYSTEMS PROVIDE RELIABLE FLUID TRANSFER FOR SPACE VEHICLES

Solving the complex problems of handling LOX, LH_2, and LN_2 to power present and future generations of space vehicles are everyday assignments at Pesco. Since 1956, Pesco has been designing and building components and systems for pumping cryogenic liquids in flight. Current projects include the development and production of lightweight centrifugal booster pumps . . . AC generators and electric motors . . . two-phase vapor-liquid separators . . . vent valves . . . liquid gas turbines . . . and system chill-down pumps.

Pesco's facilities are completely equipped for all phases of major cryogenic programs . . . from advanced research and development, special studies, and systems engineering . . . to production, clean room assembly, and final pre-launch testing.

SEND FOR PESCO'S NEW CRYOGENICS CAPABILITIES BROCHURE FC
COMPLETE INFORMATION ON PEOPLE, SYSTEMS, AND FACILITIE

PESCO PRODUCTS DIVISION Borg-Warner Corporation
24700 North Miles Road, Bedford, Ohio

xport Sales:
org-Warner International Corp. • 36 South Wabash Avenue, Chicago 3, Illinois

524-PC

Circle No. 48 on Subscriber Service Card

aerospace equipment BORG WARNE

Special Projects Division:

Cmdr. W. F. Hawley, director
3130 Munitions Building
Tel.: OX 6-7137

Interests: All Navy and most Marine Corps aircraft, rockets, guided missiles and naval ordnance—including major components and equipment, services related to their maintenance and repair and related research and development.

BUREAU OF SHIPS

WASHINGTON, D.C.

Contract Division:

Capt. G. C. Wells, director of contracts
3054 Main Navy
Tel.: OX 6-2112

Shipbuilding & Repair Purchase Branch:

C. W. Brockman
Main Navy 1N39
Tel.: OX 6-2281

Electronics Purchase Branch:

B. J. Pyrek
1N47 Main Navy
Tel.: OX 6-1803

Machinery Purchase Branch:

Coleman Morris
1N11 Main Navy
Tel.: OX 6-3886

Interests: Procurement of naval vessels of all types, including hulls, components, machinery and all major research and development on such items, and materials and appliances connected with chemical and biological warfare defense. Procurement of all vessels and watercraft needed by Army and Air Force and contracting with private shipyards for Naval ship (other than Military Sea Transportation Service [MSTS]) repair.

BUREAU OF SUPPLIES AND ACCOUNTS

WASHINGTON, D.C.

Assistant Chief for Purchasing:

Capt. H. E. Beckmeyer
0311 Main Navy
Tel.: OX 6-2136

Small Business Specialist:

H. G. Fowler
0313 Main Navy
Tel.: OX 6-4680

Interests: Procurement by the inventory control points of repair parts and related consumables required to support the major end items purchased by the technical bureaus. Procurement of a wide range of material and services required by the customers assigned for support.

BUREAU OF YARDS AND DOCKS

Contract Administration Division:

B. J. Katz, director
1A40A Yards & Docks Annex
Memorial Drive, Arlington, Va.
Tel.: OX 7-5480

Utilities Procurement Branch:

H. Treadway, manager
1A38 Yards & Docks Annex
Memorial Drive, Arlington, Va.
Tel.: OX 7-7300

Interests: Procurement of general-purpose and common-use items not assigned to the Defense Supply Agency and of other supplies and services required for the support of the field activities such as naval stations, supply centers and depots and shipyards. Procurement of services and materials related to public works, including construction and repairs at shore activities, public utilities and transportation not otherwise assigned. Also serving as a construction agency for the Air Force.

What has CryoVac done to solve
your cryogenic fluid handling problems?
JUST LOOK!
cvi
CryoVac
INCORPORATED
COLUMBUS 12, OHIO

Bayonet connections. Jacketed valves (unjacketed, too). Seal-off valves. Insulated piping. This is just a portion of our complete line of cryogenic hardware (if the page were wider we could show you more) we think will help solve your cryogenic fluid handling problems. ☐ Our engineers were unable to find commercially available components that would meet the exacting specifications necessary for our cryogenic transfer line systems. As a result they developed this complete line of proprietary cryogenic hardware. It solved our problem. And as we said, we think it will solve yours, too. Why not find out for yourself. You can by writing and asking for complete information on our cryogenic transfer line systems.

Circle No. 61 on Subscriber Service Card

He's never out of touch.

The modern Apollo has EVSTC—Extra-Vehicular Suit Telemetry and Communications.

Once out of the Lunar Excursion Module, EVSTC will keep him in voice communication, relay his respiration rate, temperature, pulse, and space suit pressure back to his spacecraft. Instructions relayed back through LEM will automatically control his suit environment.

Back on Earth—where EVSTC was provided by an ITT company—the ITT System will be coming up with more communication ideas for further interplanetary exploration and manned space stations.

ITT developments in micro-electronics have already lent themselves to advances in extra-terrestrial hardware. The low-cost Army geodetic satellite, built by ITT, is a good example.

An ITT-developed transportable ground station was the first of its kind to be compatible with NASA's Relay and Syncom satellites as well as Telstar.

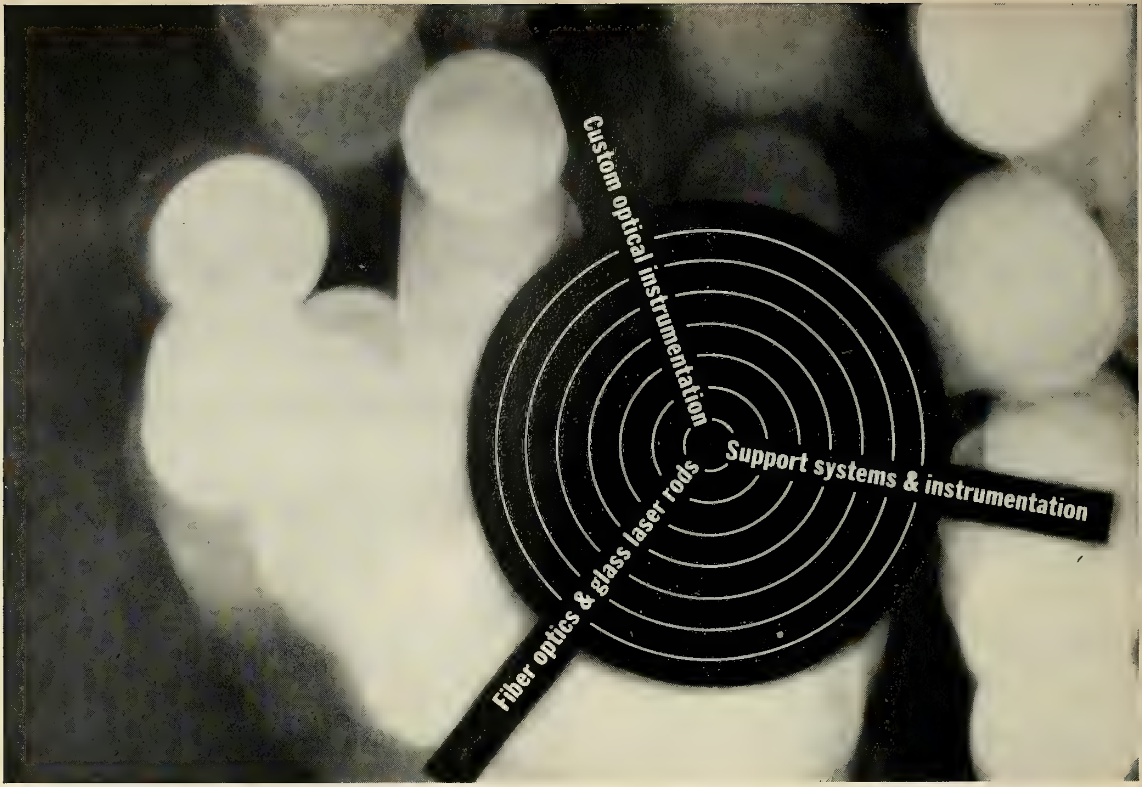
Lasers, infrared, optical sensors and gas bearing gyros for inertial guidance systems are but a few of the areas of advanced development that have made ITT the world's largest international supplier of electronic and telecommunication equipment.

International Telephone and Telegraph Corporation. World Headquarters: 320 Park Avenue, New York, New York 10022.

THESE ITT COMPANIES ARE ACTIVELY SERVING U.S. DEFENSE AND SPACE PROGRAMS: FEDERAL ELECTRIC CORPORATION • ITT CANNON ELECTRIC DIV. • ITT DATA AND INFORMATION SYSTEMS DIVISION • ITT ELECTRON TUBE DIVISION • ITT FEDERAL LABORATORIES • ITT GENERAL CONTROLS DIV. • ITT GILFILLAN INC. • ITT INDUSTRIAL LABORATORIES DIVISION • ITT INDUSTRIAL PRODUCTS DIVISION • ITT KELLOGG COMMUNICATIONS SYSTEMS • ITT SEMICONDUCTORS, DIV. ITT WIRE AND CABLE DIVISION • ITT WORLD COMMUNICATIONS INC. • JENNINGS RADIO MANUFACTURING CORPORATION

ITT

Circle No. 51 on Subscriber Service Card


Custom optical instrumentation
Support systems & instrumentation
Fiber optics & glass laser rods

How many things can you do with light?

An almost limitless number—but the performance of an optical system is entirely dependent upon the experience and ability of the designer and the skill and integrity of the manufacturer.

What do we offer? Experience...over 100 years in optics, many of them in the design and development of the most complex types of optical and electro-optical systems, many in the most advanced areas of electronics...many in devising and building sophisticated instruments that test other instruments.

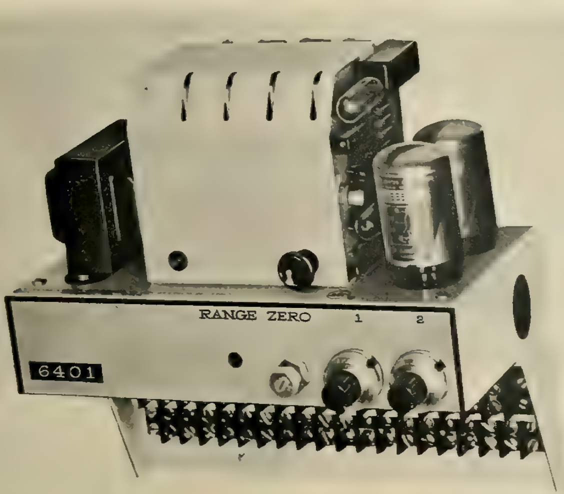
We offer capability...with more than 1,000 highly-trained scientists, engineers and production specialists, supported by the most comprehensive manufacturing facilities. And research backing...in the largest, most modern Research Center in the optical industry, where advanced studies include both basic and applied research.

Today, we are actively engaged in putting light to work in missile tracking, optical components for space reconnaissance, target detection and fire control systems, fiber optics and neodymium glass laser rods. We are also engaged in producing electro-mechanical and other systems, such as inertial guidance test equipment, which are an outgrowth of our many years of experience in building astronomical telescopes and instruments.

So, when you find it necessary to put light to work for any purpose...where materials, components, instruments or instrument systems are your problem . . . just call on us. We're readily available.

AMERICAN OPTICAL COMPANY
SPACE-DEFENSE DIVISION—SOUTHBRIDGE, MASSACHUSETTS

Circle No. 42 on Subscriber Service Card



New Product of the Week: Classifier/Controller

A solid-state classifier/controller, developed for sorting, mixing weighing or classifying by dimension, weight, force, etc., is available from Automatic Timing & Controls, Inc.

The Series 6400 features a response speed of 13 millisecs., sensitivity of 0.1% and repeatability of control action within 0.1%. The device accepts inputs from such units as differential transformers, strain gages and potentiometer transducers and produces two outputs for read-out and control.

One output is an analog signal (0 to 6v dc), directly proportional to full-scale range. The control output is in the form of relay action which can be precisely set by vernier control point setter to operate external devices.

The basic controller includes two non-interacting plug-in mercury-wetted relays with break-before-make contact action.

Circle No. 135 on Subscriber Service Card

Battlefield Radar

A battlefield radar capable of spotting a moving person at 9 mi. and a moving vehicle at 22 mi. has been announced by ITT's Laboratoire Central de Telecommunications.

The device is a pulse radar using Doppler effect for cancelling stationary targets. It has an accuracy of about a quarter degree in azimuth and 65 ft in range.

Targets are first acquired in a surveillance mode in which moving targets appear as bright spots on a cathode-ray screen while fixed targets can be eliminated or displayed as desired. The operator can use manual tracking while listening to a loudspeaker that reproduces Doppler sounds identifiable as belonging to moving objects.

Circle No. 136 on Subscriber Service Card

Foil Strain Gauges

A line of foil strain gauges for measurement of strain, force, pressure, torque and displacement has been introduced by Gulton Industries, Inc.

The K-F series, available in uniaxial, biaxial, triaxial and spiral models, are epoxy-based and have standard resistance of 120 ohms. Gauge factor ranges from 2.0 to 2.2.

Circle No. 137 on Subscriber Service Card

Testing Probe

Siliconix, Inc., is marketing the WAFERPROBE Mk III for electrical testing of transistors or integrated circuits in wafer form.

The unit is adjustable to any device pattern. It can probe up to 15 contact areas at once, and then subsequentially marks, records and steps to the next pattern automatically. A double-acting 30-to-1 reduction manipulator has been incorporated to increase mechanical accuracy and sensitivity. This feature is said to give almost instantaneous compensating response to prevent losses due to slight stepping misalignment.

The vacuum-chuck stage offers variable stepping between 12 and 320 mils, covers wafers up to 1.5 in. in diameter and tolerates a thickness variation of 3 mils within a wafer. The probe can be set to span a region 187 mils in diameter, each point independently adjustable in a 93-mil-sq. subregion. The points simultaneously probe bonding pads as small as 2 mils at a rate of 2,000 probes per hour.

Circle No. 138 on Subscriber Service Card

Protected TV Camera

Cohu Electronics, Inc.'s Kin Tel Div. is marketing the 2500 Series radiation-resistant television camera.

The unit is designed to televise quality pictures from radiation environments up to a cumulative dosage of 10^8 Roentgens and/or 10^{12} neutrons/cm^2.

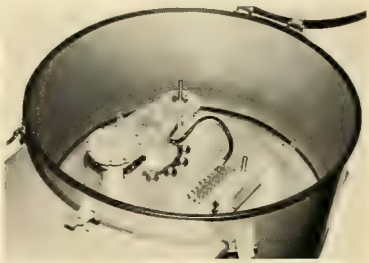
The small number of electronic components in the 3-in.-dia. cylindrical camera head assures minimum circuitry exposure to radiation, the firm explained. Resolution of the 10-mc system is in excess of 600 lines. The camera head will operate in a temperature range of —20° to 55°C without auxiliary heating or cooling and in humidity up to 100%. Camera head and pre-amp may be separated by as much as 100 ft. of radiation-resistant cable; camera operating controls may be located up to 1,000 ft. from the camera without accessory line-driving amplifiers.

Circle No. 139 on Subscriber Service Card

Dual Centrifuge

A dual centrifuge, capable of operating in three distinct modes, is being marketed by Genisco Technology Corp.

The Model 905 was developed specifically to meet requirements for calibrating and testing acceleration-sensitive instruments under varying modes and g effects. Its three modes each have a speed resolution within 0.5 rpm in the range of 30 to 1,200 rpm. The unit handles up to 64 cu. in. and 10 lbs. in dead weight within the 0-400 g range. An auxiliary table axis is adjustable with respect to the axis of the main table from 0 to 12 in. ±0.1 degree and offering repeatability within 0.1 degree.



Circle No. 140 on Subscriber Service Card

Ultrasonic Cleaner

A ultrasonic cleaning system designed for a combination of solvents and offering unlimited processing sequences is available from Blackstone Ultrasonics, Inc.

The equipment comes in three models, VR5-3, VR10-3 and VR20-3. Each has two ultrasonic tanks for removing any mix of oil and mineral salt contaminants with combinations of solvents and a third tank for vapor rinse. A spray rinse is also provided for flushing parts. Liquid capacity of the ultrasonic tanks is 5.6 gallons in the VR5-3, when filled to a 9-in. depth, to 25 gallons in the VR20-3, when filled to 12-in. depth.

Housed in a single cabinet, the system includes: ultrasonic cleaning tanks, electronic generators, distilled solvent spray rings, solvent filter system, heated solvent distillation and vapor tank, condensing coils, cooling jacket and free board drying space.

Temperature of the solvents is thermostatically controlled ±5°F in a range of 70° to 230°F. Generators can energize the magnetostrictive transducers at their resonant frequency of 20 kc per second ±1 kc per second.

Circle No. 141 on Subscriber Service Card

DC Amplifier

A solid-state dc wideband amplifier, the Accudata 102, has been developed by Denver Div. of Honeywell, Inc.

The device is primarily designed to drive electromagnetically damped galvanometers in oscillographic recording systems and, with a separate output, to drive either the input of a magnetic tape system or an external power amplifier driving a fluid damped galvanometer.

Signals from low-level, low-impedance transducers can be amplified up to 200 mv. Front panel controls provide selection of a 25-cps low-pass filter, a 500-mv calibration signal and direct or capacitive input coupling. The low-pass filter can reduce the effect of 60 cps and higher noise frequencies when the data range extends from dc to 10 cps.

Circle No. 142 on Subscriber Service Card

Pressure Indicator

A rupture-proof differential pressure indicator for measurement of level or flow is being marketed by Instrument Laboratory, Inc.

The device has as many as 32 front-adjustable set points. Minimum differential is 0 to 30 in. of water. Maximum differential is 0 to 400 psi. Maximum static pressures are up to 10,000 psi.

Circle No. 143 on Subscriber Service Card

Time Delay Relay

A subminiature static time delay relay, the Model RST, has been announced by Arnold Magnetics Corp.

The unit measures 1 15/16 x 15/16 x 17/32 in. and weighs 1 oz. Delay time is adjustable from 0.5 to 60 seconds by the addition of an external 0.5-watt resistor. It is therefore adaptable to rapid sequencing systems as well as to long tube filament "warm-up" delays, the firm says. Input voltage range is from 20 to 30v dc. Maximum voltage drop is 1.5v when delivering the rated output current of 3 amps. Operating temperature range is −10° to 71°C.

Circle No. 144 on Subscriber Service Card

Generator/Reader

A multi-purpose time code generator/reader, designed for application in data acquisition and processing systems, is available from Electronic Engineering Co.

During data acquisition, the Model 858A generates a modulated carrier time code for recording on a multi-track analog magnetic tape along with the data. In addition, a level shift code is provided for use with recording oscillographs and strip chart recorders.

In data processing applications, the unit accepts the modulated carrier time code from the tape and displays the time at playback speeds up to 200 times record speed in forward or reverse modes.

Circle No. 145 on Subscriber Service Card

Cryogenic Hose

A flexible stainless steel cryogenic hose, designed for maximum movement with high reliability, is being marketed by Flexible Metal Hose Manufacturing Co.

The hose is available with tube or pipe dimensions from 0.25 to 12 in. I.D. or with end couplings to suit individual applications in any length. The cryogenic lines are said to maintain gas and liquid tight sealing over a wide range of environmental conditions. The hose is corrosion resistant, lightweight and available for operation from vacuum to high pressures, the company said.

Circle No. 146 on Subscriber Service Card

Planar Transistors

A series of epitaxial planar transistors, designed specifically to operate at low collector current in applications requiring high current gain, is available from Norden Div. of United Aircraft Corp.

The V222 will deliver a minimum dc current gain of 140 with a collector current of 0.1 ma and a V_{ce} of 5v. The T_s on all units is typically 20 nanosecs. Junction capacitance is less than 2 pfd. F_t is typically 1,000 mc.

The units are available in packages ranging from TO-51 to TO-5, including flat packs and meet MIL-S-19500C specifications.

Circle No. 147 on Subscriber Service Card

Nucleonic Thickness Gauge

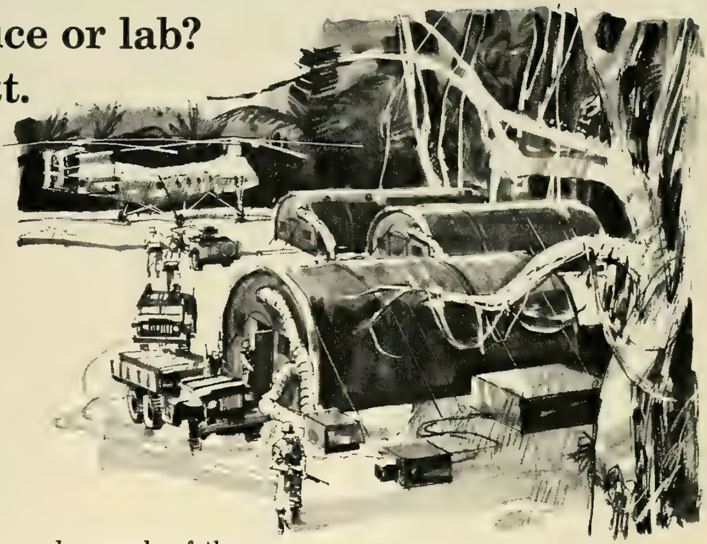
A nucleonic thickness gauge, which probes material thickness or weight per unit area with gamma rays, is available from Giannini Controls Corp.

Weighing 12 lbs. and operating on-line, the gauge eliminates the necessity of shutting down the line to remove a test sample. Thicknesses from 10 to 500 mils can be measured.

According to the firm, the gauge features accuracy and continuous reading which reduce set-up time and permit holding product dimensions close to specifications.

Circle No. 148 on Subscriber Service Card

Want a portable field facility that sets up in 30 minutes and provides all the comforts of a modern office or lab? Just ask Garrett.



When you ask, here are some of the answers you'll get:

Garrett's portable gas turbine power pack and inflatable or expandable shelter give you all the comforts of a completely controlled environment—whether your base is in the middle of the Sahara one week or moved to the Arctic Circle the next.

It works this way:

The power pack provides electricity, refrigeration, air heating, air pressure, and water heating and pumping.

You simply connect water and fuel lines. Start the turbine which inflates and deflates the structures pictured here, or set up the expandable shelter—and you have a modern, well-lighted, temperature-controlled facility—fully protected from sun, wind, rain, snow, ice, heat, humidity, dirt and insects.

You need just five men and half an hour to get the units up and operating.

How do you transport the units? Easy.

They come packaged in containers that fit nicely on the bed of a truck or in a helicopter sling or in the cargo hold of an airplane.

A good example of these new field units is the MUST complex that Garrett-AiResearch is building for the U.S. Army Medical Service. MUST means Medical Unit, Self-contained, Transportable, and comprises a complete 400 bed evacuation hospital.

Outputs from a typical MUST power pack include: 90 kw 400-cycle and 10 kw 60-cycle electrical power, 20 tons of refrigeration, 520,000 BTU/hr. air heating, 60,000 BTU/hr. water heating.

The heart of the power pack is a small gas turbine—the only type of power that can give you so many outputs from a single lightweight unit.

Only Garrett has so much experience in designing and applying small gas turbines to this type of system.

The components are designed and produced by our two AiResearch Manufacturing Divisions and Air Cruisers Division. In addition, we also offer total system management responsibility as well as integrating the components into the complete system.

Typical applications of the new field units are: chemical and biological protection; radar installation, communications bases, civil defense shelters; and oil, mining, and construction operations.

Please direct inquiries to AiResearch Manufacturing Division, Phoenix, Arizona.

Garrett
***is* experience**

GARRETT

AiResearch Manufacturing Divisions
Los Angeles • Phoenix

Circle No. 41 on Subscriber Service Card

Solar Cell Process

The successful processing of production quantities of cadmium sulphide thin-film solar cells, with double the performance of existing Cd S thin-film cells and 25 times the area of silicon single crystal cells, has been announced by Clevite Corp.

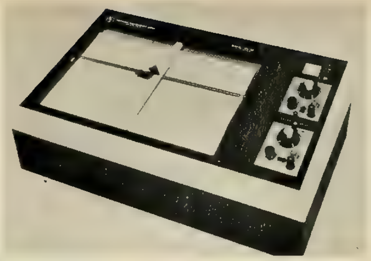
The cells are currently made in a 3 x 3-in. size with an active area of 50 cm^2. Efficiency of the cells, according to a company spokesman, ranges from 4 to 6%.

When alternated between ± 60°C, the cells have a tested life of approximately 3,000 cycles. The developer also said that Cd S thin-film cells indicate on the order of 100 to 1,000 times the resistance to Van Allen radiation over silicon solar cells.

Circle No. 149 on Subscriber Service Card

X-Y Recorder

Houston Omnigraphic Corp. is marketing the Model HR-98T X-Y recorder. The unit features 1 mv per in. sensitivity, switch selectable to 10 v per in. in five steps with vernier control between ranges. Input impedance is 100 k ohms constant; accuracy is 0.25%. The recorder also offers temperature compensated zener reference supplies and X-axis time sweep switch selectable from 0.05 to 2 in. per sec. in six steps.



The model is designed to provide complete accessibility to electrical and mechanical components. All mechanical components are mounted on the recording bed which swings into a vertical position for admittance to the mechanical drive assemblies and X and Y-axis amplifiers.

Circle No. 150 on Subscriber Service Card

Shaft Encoder

A shaft angle encoder with a guaranteed lifetime of 6 x 10^8 revolutions at 200 rpm is being marketed by Vernitron Corp.

The Type VBE 18-SB13 provides accurate read-out at 500 rpm, where interrogation is required while slewing. Momentary speeds to 1,500 rpm do not damage the encoder, the firm says. Accuracy of the unit is guaranteed over a temperature range of −65° to 85°C. Where required, the brush-disc design may be adapted to continuous operation at 125°C.

The unit generates a natural binary output using a self-selecting U-Scan logic. Thirteen bits are generated in 64 turns of the input shaft, resolution being 128 counts/turn.

Circle No. 151 on Subscriber Service Card

Current Regulator

A miniature constant current regulator, providing regulation of 1%, is being marketed by Electronic Modules, Inc.

The unit is a solid-state device combining silicon transistors and diodes in a welded cordwood assembly. The two terminal regulator can be in series with the current line, therefore needing no reference to ground.

Characteristics include a temperature coefficient of 0.03% per degree C; threshold voltage of 9v; and current stability of 1%. Maximum power dissipation ranges from 1 to 3 watts at 25°C case and from 0.4 to 0.87 watt at 25°C ambient. Maximum voltage is 50 to 55v interelectrode and 120 to 155v reverse polarity.

Circle No. 152 on Subscriber Service Card

Elliptical Waveguide

Heliax elliptical waveguide, designed to replace rigid waveguides for all microwave relay and radar applications in the 3.7 to 11.7-gc range, is available from Andrew Corporation.

The waveguide consists of a convoluted copper tube of elliptical cross section and has attenuation equal to or lower than conventional rigid rectangular waveguide. This attenuation is generally one-fourth that of flexible waveguide and one-tenth that of flexible coaxial cables, sometimes used for transportable electronic systems, developers maintain.

Circle No. 153 on Subscriber Service Card

Flame-Plated Cermet Coating

A flame-plated coating, designed to combine the wear resistance of a ceramic with the mechanical and thermal shock resistance of a metal, is available at present on an experimental basis from Linde Div., Union Carbide Corp.

The LC-9 coating is said to exhibit properties which make it a seal material for use at temperatures up to 1,800°F. Linde also said that LC-9 shows promise as a textile thread guide material characterized by little or no polymer pickup and the ability to attain a wide variety of finishes.

Circle No. 154 on Subscriber Service Card

What's the shortest distance between these 2 points?

Los Angeles
Cape Kennedy
San Diego
Houston
New Orleans
Melbourne

National's direct line.

We call it our "Rocket Run." It's the only direct jet service between the major space centers of the west and Melbourne (closest airport to Cape Kennedy.)

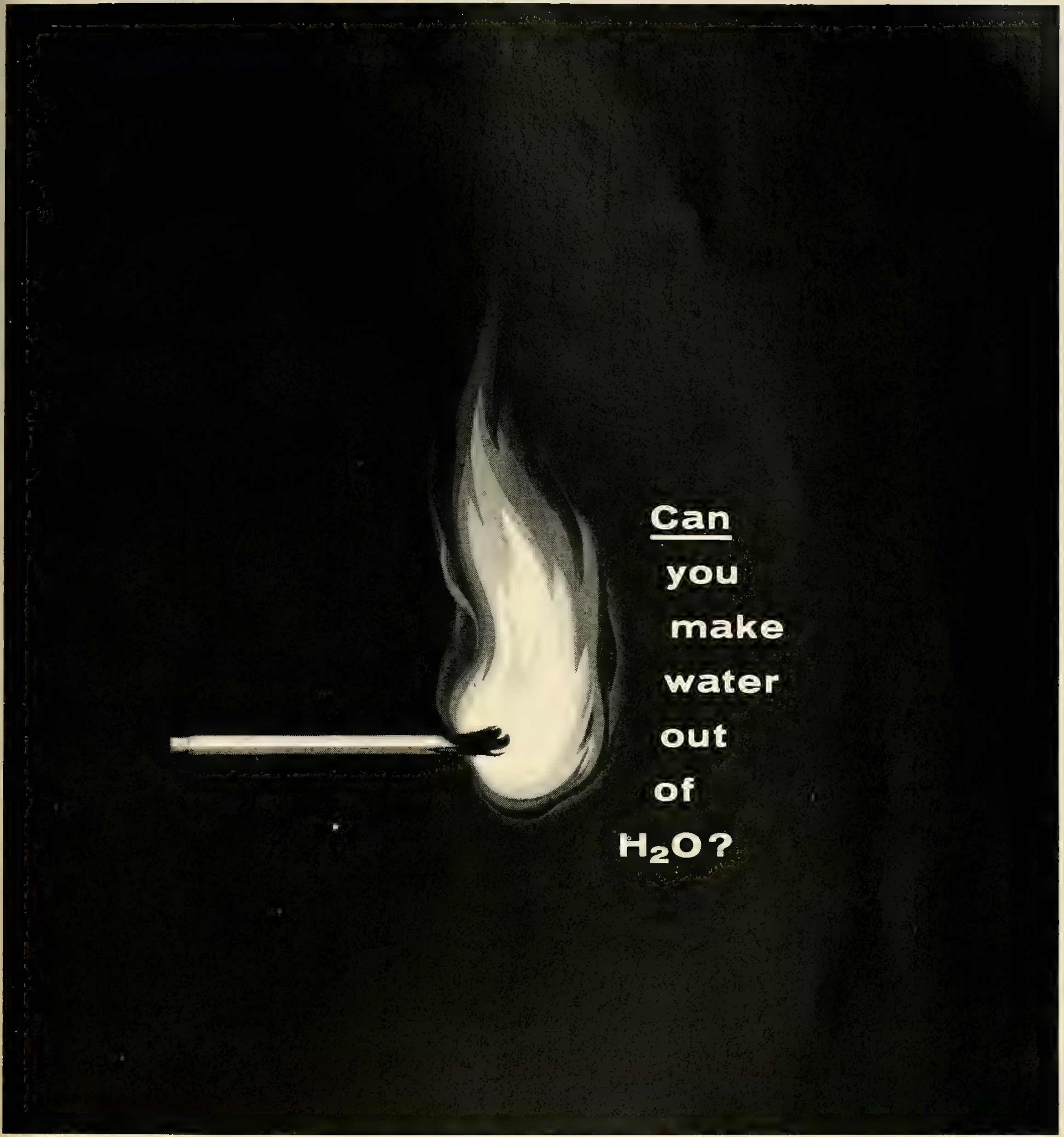
You jet between Los Angeles and Melbourne without changing planes. National also serves the key space age cities along the east coast.

Is this any way to run an airline? You bet it is.

Jet National
coast to coast to coast

Circle No. 62 on Subscriber Service Card

CAREER OPPORTUNITIES AT DOUGLAS


Can you make water out of H_2O?

Two parts of hydrogen and one of oxygen leave a thirsty man high and dry. But give him a match to ignite the gases and a jar to catch and condense the steam, and he can drink the result.

Likewise, capability in the individual sciences and skills involved in developing great aerospace and defense systems isn't enough. The right combining agency is essential.

That's where Douglas comes in. It has the ability to make big programs jell. And its comprehensive approach to technological achievements make it an ideal place for young engineers and scientists to grow in professional stature. At Douglas, you not only will have wide opportunities in your own discipline, but have every chance to integrate it with others as you contribute to the development of advanced space, defense and electronic systems.

If you would care to join us please send resume to Mr. I. F. Snodgrass at

DOUGLAS
MISSILE & SPACE SYSTEMS DIVISION

An equal opportunity employer / **2700 Ocean Park Blvd., Santa Monica, California**

Cleaning Solvent

A cleaning solvent specifically developed to meet the requirements of aerospace and electronics industries is available from Dow Corning Corp.

The Dowclene WR is a chlorinated hycrocarbon with a combined soluble and insoluble residue count of less than 1 part per million. It has a maximum allowable vapor concentration of 500 parts per million and no fire or flash point measurable by standard methods, developers say.

Specifications include a specific gravity at 25/25°C of 1.317 to 1.321. Maximum nonvolatile residue is 1 ppm. Distillation range at 760 mm Hg is 73 to 86°C.

Circle No. 155 on Subscriber Service Card

Electronic Filter

An electronic filter offering either linear phase or Butterworth characteristics in a frequency range of 10 cps to 10 kc is available from Dynamics Instrumentation Co.

The Model 6371-S6 provides tenth-decade steps with 36-db per octave terminal slope while processing dc information. Specifications include a gain of 100 ±2% and gain stability of ±0.1% on all settings. Input impedance is 10 megohms; dc drift is ±5 millivolts or less in 1 hr. Output is ±10v, ±100 ma, maximum, with an impedance of 1 ohm or less at dc. Time delay is 4 millisecs. for 100 cps of bandwidth.

Circle No. 156 on Subscriber Service Card

Pulse Transformer

Electro-Nuclear Laboratories, Inc., has developed a 4-lead device that serves as a dc, ac and pulse transformer.

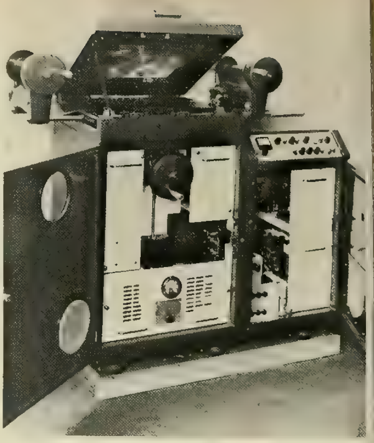
The device conveys the information, singly or superimposed, through the optical emission of a GaAs source incident on a matched photosensitive silicon detector of high-current output. Optical coupling permits true electrical isolation, the firm says. High-voltage isolation up to 25 kv can be achieved in special packaging.

The unit is available in a single TO-5 or TO-18 case.

Circle No. 157 on Subscriber Service Card

Photo Viewer

A positive/negative viewer that offers a new method of photographic negative evaluation for aerial survey and photo reconnaissance work has been introduced by Ampex Corp.



Based on the use of a high-definition TV system, the viewer enables an observer to pick out details in photographs without having to wait for positive prints. Pictures are displayed on TV monitors. The viewer can instantly produce the effect of a variety of printing exposure times and can magnify selected areas of the photograph up to 20 times. Controls are provided to correct for over or under exposure and other anomalies and an "edge enhancement" control can instantly highlight details, say developers.

Circle No. 158 on Subscriber Service Card

Antenna System

A conical scan tracking antenna, featuring dual log-spiral elements operating in a telemetry band from 890 to 3,000 mc, is available from Jasik Laboratories, Inc.

The Type 296 has a scanning rate of 15 cps. The double-spine scanner offers both right- and left-hand circular polarization, remotely selected. Input VSWR is less than 2.5:1; crossover level is nominally 2.5 db and axial ratio is nominally 3 db. Antenna gain varies from 23 db at 890 mc to 33 db at 3,000 mc when used in an 8-ft. paraboloid. The system is mounted in an 8-ft. dish with a 35.8-in. focal length.

Circle No. 159 on Subscriber Service Card

Transducer

Fairchild Controls Div. of Fairchild Camera & Instrument Corp. has developed a frequency-modulated output pressure transducer for use in oceanography.

The device employs a Telewire—a vibrating wire suspended in a magnetic field. As the wire is tensioned or relaxed through pressure diaphragm motion, it produces a frequency modulated output as a function of pressure changes. Electrically, the wire forms one leg of a bridge circuit. The electromotive force developed in the wire is

ELECTRICAL / ELECTRONIC
ENGINEERS
DESIGN · ANALYSIS · TEST

BSEE, plus appropriate experience in any of the following areas:

- Communications
- Computer Software
- AGE Systems
- Field Engineering
- Circuits/Systems
- Electro-optics
- Microwaves
- Power Systems
- Propulsion
- Instrumentation
- Guidance & Controls
- Batteries

Write: Lockheed Missiles & Space Company, Professional Placement Staff, Suite 530, 599 North Mathilda Avenue, Sunnyvale, California.

LOCKHEED
MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

AN EQUAL OPPORTUNITY EMPLOYER

amplified and the output is partially fed back to the bridge amplifier to sustain oscillation.

Specifications include a pressure range of 0 to 1 psia to 0 to 500 psia and 0 to 750 psig to 0 to 15,000 psig. Overpressure is 25 to 50%, depending on depth. Frequency in IRIG bands is 3 to 22 kc. Repeatability and hysteresis is ±0.15% for selected pressure ranges. Temperature range is 28° to 100°F (no heater required). Maximum error is ±0.025% F.S./°F.

Circle No. 160 on Subscriber Service Card

Heater Cathode

Sylvania Electric Products, Inc., has developed a low-drain heater cathode assembly that produces lightweight cathode ray tubes that can operate 400 hours on a #6 battery cell.

The tubes, developed primarily for use with transistorized equipment where portability is a prime requirement, consume less than 6% the power required by a normal CRT, the firm says. The device is 0.05 in. in diameter and 0.011 in. thick. Compared with conventional CRT's, the assembly has an external radiating surface of 0.0054 sq. in. compared to 0.136 sq. in., a ratio of 25 to 1 It has a 1.5-v heater rating and 140-ma current rating, compared with 6.3v, 600 ma for conventional units.

Circle No. 161 on Subscriber Service Card

Vacuum Furnace

A vacuum furnace for heat treating of small metal parts has been announced by ABAR Corp. The equipment is designed for stress relieving, weld annealing, vacuum de-gassing and silver brazing at temperatures to 2,200°F and vacuums as low as 1 x 10^{-6} torr.

The unit has a high-speed quenching feature made possible by gas-cooling jets in the hearth plate. A typical cooling cycle from 1,800° to 800°F in 10 minutes can be repeated consistently without shortening heating-element life below the normal 12-month period, the firm says. Hot zone diameters up to 18 in. may be specified without sacrificing temperature uniformity and close temperature control.

Circle No. 162 on Subscriber Service Card

Video Monitor

Conrac Div. of Giannini Controls Corp. has developed a 9-in. transistorized video monitor, designed to provide professional signal quality on less than 50 watts power.

The Model RNB9 incorporates a tube developed for improved geometry and small spot size. The tube is said to assure crisp 800-line center resolution and 700-line corner resolution. Picture height and width can be adjusted from the front of the monitor to show all four sides and corners. The picture will be approximately 2 sq. in. larger than that on conventional 8-in. tubes, the firm said.

The unit is available with a portable carrying case or in a rack mount configuration.

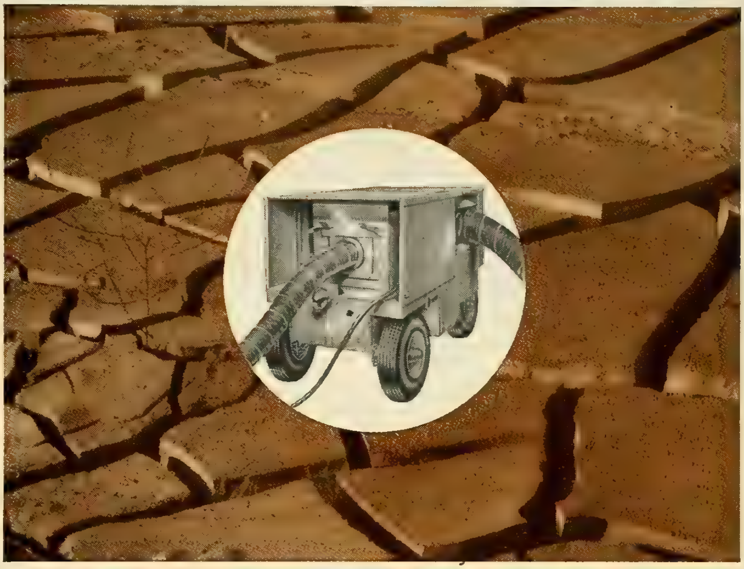
Circle No. 163 on Subscriber Service Card

Beacon Transmitter

Conic Corp. is marketing a crystal-controlled, all-solid-state transmitter designed for use as a CW source in missile/space applications.

The Model CTB-202-03 measures 3.5 cu. in. and weighs less than 3 oz. Frequency range is 215 to 260 mc, with 400 to 406 available as an option. Frequency stability is 0.01% standard, but 0.005% models are also available. Power output is rated at 150 mw minimum when operating into a 50-ohm load. The device is capable of operation at temperatures from —30° to 80°C, accelerations of 100 g's in each axis, shocks of 100 g's, half-sine, for 11 millisecs. in each axis and vibrations of 20 g's peak from 20 to 2,000 cps in each axis.

Circle No. 164 on Subscriber Service Card



No Bake Job is too tough for

AAF ENVIRONICS*

If you need it, we can furnish a controlled environment for baking mud flats. A more practical example of our capability, however, is the packaged environment we recently produced for heat curing solid rocket propellant cores. This job required our equipment to be self-sufficient, mobile and explosion-proof, and provide precise control of temperature, humidity and air purity.

An AAF Environics team moved quickly . . . designing and building a modified version of the reliable Model H-40 Explosion-Proof Heater. It did the job. Designated Air Force Type HDU-13/M, the H-40 was originally developed by AAF to provide 100,000 BTU/hr for purging jet fuel tanks and supplying heated air in hazardous locations.

Can we help you with environmental control problems? Phone or write Defense Products Group, American Air Filter Co., Inc., 1270 N. Price Rd., St. Louis, Mo. 63132. Ask for Bulletin D-240.

American Air Filter

* *Our total system approach to R&D, production and engineering management of packaged environments involving heating, ventilating, air filtering, refrigeration, humidity control and purification.*

AAF

Circle No. 63 on Subscriber Service Card

Nose Cones

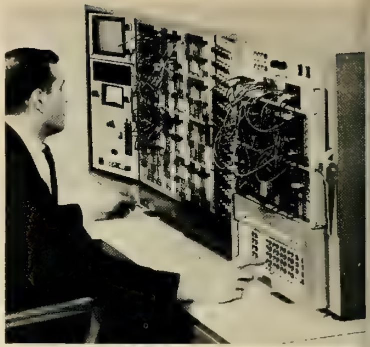
B & K Instruments, Inc., is marketing a microphone nose cone to reduce noise from high-velocity wind when making measurements. The unit also provides omni-directional response for standard condenser microphones.

The unit is available for 1, 0.5 and 0.25-in. condenser microphones and screws directly onto the microphone housing in place of the normal protective grid.

For measurements under wind velocity up to 25 mph, the cone can remove 10 to 12 db of pure wind noise. When used to obtain omni-directional characteristics from a 1-in. microphone, the cone provides sensitivity within ±1, —6 db at 8,000 cps for 360-degree incidence as compared to the zero incidence.

Circle No. 165 on Subscriber Service Card

Digital Logic System



A general-purpose digital logic system that adds hybrid capabilities to small analog computers has been announced by Electronic Associates, Inc. The system can be linked to any general-purpose analog or digital computer or may be used autonomously as an aid to digital instruction or design.

In the DES-30, digital operations are performed by modular building blocks designed to relieve the programmer of details of timing, loading and other circuit considerations. All facilities are designed to provide necessary interface or features to enhance hybrid problem setup with a minimum of programming and "debugging" effort.

Other features include: synchronous logic, internal clock and provision for external signal triggering; a 540-hold removable patch panel and one type of flip-flop modules which can be used as a shift register, counter or as four individual flip-flops. Operations can be as slow as 1 cps.

Circle No. 166 on Subscriber Service Card

Welding Power Supply

Model 1-123-01 high production power supply is the first dc stored-energy supply to provide a continuous repetition rate of 400 welds per minute at 130 watt-seconds, according to its developers, Weldmatic Division/Unitek.

The unit is designed for welding electrical and mechanical parts as fed by high-speed fixtures and jigs in production operations.

Pulse durations from 1 to 4 ms are selected by switching transformer connections. The weld pulse is initiated by an external contact closure. Energy storage range: 5 to 130 watt-seconds. Voltage regulation is ±1% for line voltage fluctuations from 100 to 130v ac 60 cycles. The unit measures 16 x 23 x 32.5 in. and weighs 275 lbs.

Circle No. 167 on Subscriber Service Card

Synchros

Bowmar Instrument Corp. has introduced a line of synchros in six sizes, from 8 to 23.

The units are for 60- or 400-cycle service with 26-, 90- and 115-v primaries

Trailers by Dorsey for Link A3J-1 Trainer

DORSEY TRAILERS

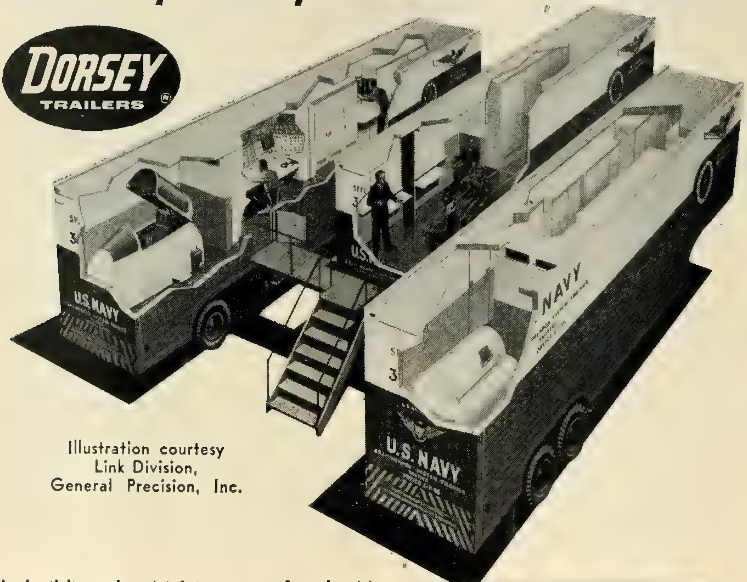


Illustration courtesy
Link Division,
General Precision, Inc.

In building the A3J-1 system for the Navy, Link made significant advances in the state-of-the-art of aviation training. Special vans built by Dorsey house the three units—flight simulator, bomber-navigator trainer and tactical simulation trainer.

For any project involving mobile equipment our Special Products Division engineers can hold time and cost to a minimum and insure reliability as well. They have successfully completed a wide variety of R & D assignments on trailers for electronics installations as well as vans to haul delicate cargoes. Dorsey builds special trailers to any desired stage of completion. Can we help you? If urgency dictates, we can be at your desk within hours.

The accoustical ceiling, special lining and floor installed by Dorsey are shown in this photo of the briefing room. All three trailers are insulated and air conditioned.

Write for our brochure, *"Ground Support Equipment"*

DORSEY
RESEARCH & DEVELOPMENT CENTER

Special Products Division

DORSEY TRAILERS/ELBA, ALABAMA

(AREA CODE 205—897-2241)
Subsidiary of The Dorsey Corporation

Circle No. 64 on Subscriber Service Card

and 11.8-, 57- or 90-v secondaries. Primaries are rated in a range from 0.06 watts for control transformers to 6 watts for torque transmitters. Electrical error is typically 7 minutes, maximum.

Size 8, 10 and 11 units are designed for 400-cycle operation and meet MIL-S-20708 specifications. Size 15, 18 and 23 units are available for either 400- or 60-cycle service. Stainless-steel construction is used throughout the series; all units incorporate a plastic terminal block.

Circle No. 168 on Subscriber Service Card

Phase-Lock Synchronizer

A microwave phase-lock synchronizer, the Model 244, is being marketed by LFE Electronics.

The instrument permits klystrons, BWO's and other voltage-tunable sources to be phase-locked to a crystal reference and operated as ultrastable oscillators over a 2 to 15-gc range. It may be used with a 1- or 5-mc external reference oscillator to produce microwave frequencies with crystal or atomic reference accuracies. Long-term drift is ±5 parts in 10^{10} per day for standard quartz oscillators and ±5 parts in 10^{11} absolute for a cesium atomic standard.

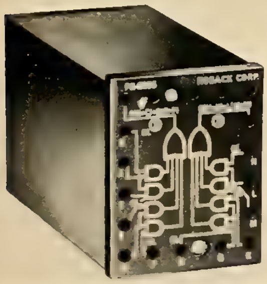
Using an internal reference crystal, the instrument achieves long-term stabilities of 1 part in 10^7 per 10°F with short-term noise of 1 part in 10^9 over a bandwidth of 1 to 100 kc.

Circle No. 169 on Subscriber Service Card

Breadboard Module

A breadboard module that incorporates the digital logic function of A(B + C) + D(E + F) in a single plug-in package has been announced by the Roback Corp.

Designated the Pulse Gate PG-6256, the module provides a nominal 1.5-microsec. positive pulse output when any of four input clock lines are triggered with a "1" level. Two separate gate lines provide an AND/OR function between the four gate inputs. Four standard loads may be driven from the output.



Circle No. 170 on Subscriber Service Card

"Clean" carbon materials from...

HITCO

REDUCE ION RELEASE ON RE-ENTRY

Clean ablation systems which assure minimal ion release provide a key penetration aid in helping high performance re-entry vehicles reach their targets. Clean systems can be guided more accurately because ion interference with controls is greatly reduced...and re-entry vehicles are safer from detection when tell-tale ion release is rigidly curtailed.

Purity and low thermal conductivity of materials are vital to ballistic missile penetration. HITCO's new version of CCA-1 carbon cloth—a low alkalinity carbon fabric designated CCA-1 (1641)—has a thermal conductivity of less than 6.5 K at a mean temperature of 300°F.

The total alkalinity content of this fabric is guaranteed not to exceed 400 parts per million, and its maximum sodium impurities do not exceed 150 parts per million.

HITCO is reducing the impurities of its superior CCA-1 (1641) ablative material even further. For details, write for HITCO Data File SA-2957-1.

HITCO®
H. I. THOMPSON FIBER GLASS CO.
1600 WEST 135TH STREET, GARDENA, CALIFORNIA

Circle No. 65 on Subscriber Service Card

Microscope Lens

A high aperture microscope objective lens utilizing an interferometer for the examination of surfaces by reflected light is available from Watson, Barnet, England.

Producing interference fringes showing the contour on a range of surfaces by monochromatic or white light, the device fits most microscopes using the standard R.M.S. screw thread, converting the instrument into a surface finish interference microscope. A shutter which will cut off the interferometer leaving ordinary bright field incident lighting is incorporated.

A precision levelling stage is supplied with each objective. The objective has a focal length of 8mm; the numerical aperture is 0.63. Resolving power is 0.6 microns horizontally and less than 0.1 the fringe vertically.

Circle No. 174 on Subscriber Service Card

Triggered Generators

Two triggered generators capable of local or remote control and providing simultaneous sine, triangle and square wave outputs over the frequency range of 0.008 cycles to 1 megacycle have been introduced by Wavetek.

Upon receipt of a trigger signal, one cycle is generated, the frequency of this cycle being determined by the dials and range control. If the trigger is a long gate pulse numerous cycles, the length of the gate, will be generated.

Models 106 and 107 feature 5-nanosec. rise and fall time of the square wave, power supply options of rechargeable nickel cadmium batteries on standard ac line and less than 1% distortion.

Circle No. 175 on Subscriber Service Card

Vacuum Relays

A series of vacuum relays, capable of switching up to 12 kv, has been developed by High Vacuum Electronics, Inc.

The Models H-14 and H-16 are supplied with a DPDT contact arrangement and have an operating time of 18 ms with a nominal coil voltage of 26.5v dc. Normal operating voltage is 8 kv (air) or 12 kv (oil) for the H-14 and 12 kv (air) and 18 kv (oil) for the H-16.

Circle No. 176 on Subscriber Service Card

Plate Application

A hermetically sealed plate application, containing 1,218 contacts and fluid coupling lines, has been announced by Deutsch Co.'s Electronic Components Div.

The plate was designed for vacuum chamber/space applications and offers contacts in sizes 16, 20 and 22, as well as for thermocouples. The connectors can withstand temperatures from −250° to −300°F and have a leak rate of less than 0.001 micron cu. ft. per hour at one atmosphere differential. The plate assembly measures approximately 11.5 x 13 x 0.25 in. and withstands a vacuum of 1 x 10^{-6} mm. Hg.

Circle No. 177 on Subscriber Service Card

Diamine Curative

Curalon L, a diamine curative for urethane polymers enabling the production of large castings and hard parts with high isocyanate (NCO) content polymers, is being marketed by the Chemical Div., United States Rubber Co.

Possessing four to five times longer pot life than is obtainable with other diamine curatives, the polymer mixes stay pourable long after conventional diamine systems become viscous and unworkable, according to the firm.

Curalon M, a super-cooling, diamine curative with low melting point, reasonably long pot life and fast cure, is also available.

Circle No. 178 on Subscriber Service Card

Single Crystals

Three single crystals have been introduced by Electronic Space Products.

Beryllium oxide, grown in hexagonal prismatic forms, is available in nominal size, approximately 1 to 2-mm. in diameter, and also in 3 to 4-mm. sizes. Purity is 99.99%, not including a maximum of 1,000 ppm molybdenum.

Beryllium silicate single crystal is available in sizes of 1 to 5 mm. in diameter and are spherical in shape and prismatic.

Zirconium dioxide, an angular crystal nearly cubic in form, is 1 to 2 mm. in diameter.

Circle No. 179 on Subscriber Service Card

Insatiable!

Demand effective filtration? Extra high flow of liquid or gas? Try a Fluid Dynamics hungry filter. In the FP Series, port sizes range from ½" to 12". Wire cloth elements of all-welded stainless steel are pleated to provide an extra large capacity of effective filtration area. Pot-type construction permits quick, easy servicing of the element. Pressures? Up to 3000 psi. Temperatures? Down to −423°F. What else? Write for FP Series Data Sheet MRP and see.

FD®

FLUID DYNAMICS, INC., P.O. BOX 10, MORRISTOWN, NEW JERSEY (201) 539-8100

Circle No. 66 on Subscriber Service Card

Liquid Control System

A liquid hydrogen level control system which provides control accuracies of ±0.25 in. has been announced by Cryogenics, Inc.

The unit introduces no electrical output into the dewar. A sensor with an operating principle based on the "raspberry" phenomenon is incorporated into a probe configuration. The system provides fixed dual point control and will sense the liquid interface even when gas and liquid are at the same temperature. When the level of liquid drops below the fixed lower limit, a control relay is energized which in turn activates a flow control valve, initiating flow.

The control valve remains open until the level of liquid rises to the fixed upper limit. Since the sensing probe is passive, it will not interfere with experimental measurements or functions.

Circle No. 171 on Subscriber Service Card

Universal Counter

Atec, Inc., has announced the Model B535 counter, which can be used as a deviation meter, a normalized rate counter or a preset counter.

The device is capable of varying the time base in 10-microsec. increments, allowing one rate, such as pulses per second, to be converted into direct reading units such as gallons per minute. Frequency measurement for input is 2 cps to 350 kc with gate times of 10μsec. to 100 secs. Preset measurement is 2 cps to 350 kc with a range of 1 to 100,000 steps per cycle. Input impedance is 1 megohm; input sensitivity is 0.1v RMS. Accuracy is ± count accuracy of the frequency standard.

Circle No. 172 on Subscriber Service Card

Shock Indicator

A compact accelerometer, designed to monitor shock forces simultaneously from all directions and register excesive impact forces, has been introduced by Impact-O-Graph Corp.

The "Omni-G" shock indicator measures 1.5 in. high and 2⅙ in. in diameter and weighs 2 oz. It is available in sensitivity ratings from 5 to 150 g's in 5-g increments. Calibrations as precise as 1 g are available on order. Repeatable accuracy is assured within 10% of the rated g value.

The device consists of two pairs of spring-loaded steel balls housed in transparent, impact-resistant plastic. The retaining springs are calibrated to withstand forces up to the instrument's rated value. When impact or shock forces from any angle exceed the rated value, the balls are dislodged.

Circle No. 173 on Subscriber Service Card

FUSED QUARTZ

comes in a variety of shapes and types from General Electric. Backed by the most complete technology and engineering, G-E Quartz will help fill all your fused quartz requirements. For first-hand help, write or call:

EASTERN
133 Boyd Street
Newark, New Jersey
Area Code 201 824-5200

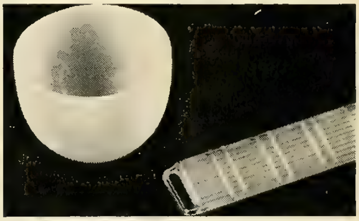
NEW ENGLAND
50 Industrial Place
Newton Upper Falls 64, Mass.
Area Code 617 332-6200

WESTERN
2747 South Malt Avenue
Los Angeles, California
Area Code 213 723-2541

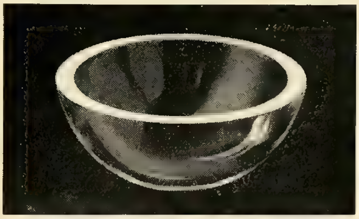
MIDWESTERN
Euclid Avenue and Campbell Road
Willoughby, Ohio
Area Code 216 266-4001

CANADA
Canadian General Electric Company
165 Dufferin Street
Toronto 3, Ontario, Canada • Telephone 532-4421

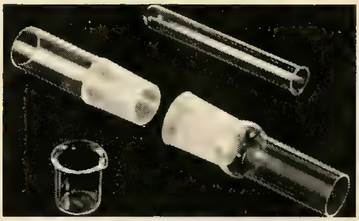
OPTICAL—your choice of infra-red and ultra-violet in five optical grades including our Type 151 Schlieren grade fused silica.



SEMI-CONDUCTOR maximum-purity crucibles for crystal pulling, slice boats, and tubing for zone refining and diffusion applications. For heavy-duty melting, ask us about our new Type 510 crucible.



MICROWAVE, ELECTRONIC fused quartz applications with insulating and dielectric properties needed at high temperatures. Radomes made to your specifications.



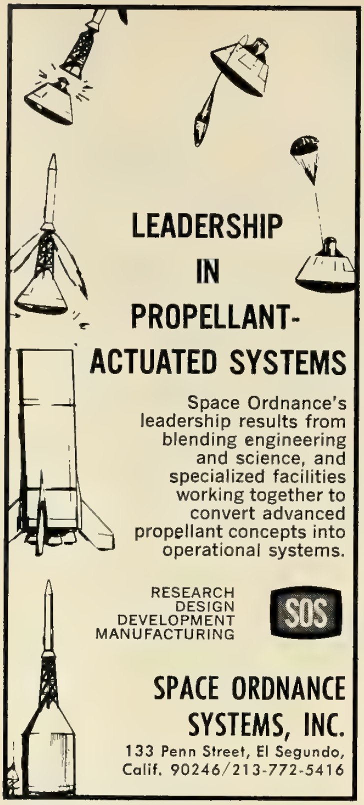
LABORATORY QUARTZWARE, made from our high-purity Type 204 fused quartz and fabricated to your specs. G-E's quality product is essentially chemically inert and has high thermal shock resistance.

FIBER for ablative and radome applications. Comes in yarn, roving, wool and matt, readily fabricated into cloth or tape.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle No. 67 on Subscriber Service Card


LEADERSHIP
IN
PROPELLANT-
ACTUATED SYSTEMS

Space Ordnance's leadership results from blending engineering and science, and specialized facilities working together to convert advanced propellant concepts into operational systems.

RESEARCH
DESIGN
DEVELOPMENT
MANUFACTURING

SOS

SPACE ORDNANCE
SYSTEMS, INC.
133 Penn Street, El Segundo,
Calif. 90246/213-772-5416

Circle No. 68 on Subscriber Service Card

Engineers

To $17,000—FEE PAID

- *Ablation Engineers—Material and Protective Coatings
- *Missile Structural Design Loads
- *Aircraft Flutter Engineer
- *Thermodynamics, Aircraft Propulsion
- *Propulsion Test—Liquid and Solid

Prominent East Coast aerospace company will pay all expenses incidental to employment. Immediate interviews for qualified engineers. Please send your resume in confidence, stating your present salary, to:

Harry L. Brisk

ACCREDITED PERSONNEL

12 South 12th Street,
Philadelphia, Pa. 19007

Circle No. 69 on Subscriber Service Card

Gas Analyzer

F & M Scientific Corp. has developed a gas analyzer, designed to give a complete qualitative and quantitative analysis of a gas mixture in a single run.

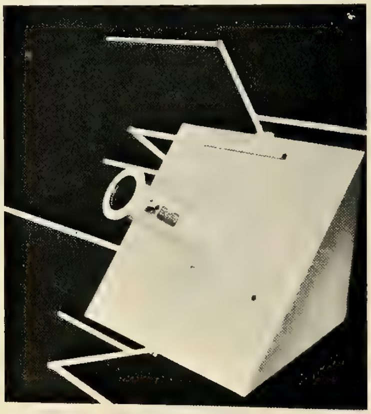
The Model 100 can analyze traces gases as well as major constituents. According to developers, the unit can detect neon in room air (18 parts per million) in a sample size of 250 microliters. Sensitivity to other permanent gases of the same order; it also responds quantitatively to concentrations up to 100% and is not damaged by oxygen.

The instrument is a dual-column, a dual-detector, dual-recorder gas chromato graph. It can be equipped with a gas sampling valve accurate to ±0.5%.

Circle No. 180 on Subscriber Service Card

Primary Feed Antennas

A series of log periodic type primary feed antennas, ranging from 250 to 4,000 mc, has been introduced by Dorne and Margolin, Inc.



The DM AR6 feeds are said to minimize phase center displacement of the primary feed from the focal point of the reflector. Trapezoidal in form, they are said to achieve higher radiator efficiency as a result of their nearly equal E and H plane radiation patterns. Phase error, referenced to the reflector edge, is less than 0.2λ, over the entire 10:1 bandwidth in the series.

Circle No. 181 on Subscriber Service Card

Portable Control Console

A control console for monitoring plasma spray operations has been developed by the Plasmadyne Div. of Giannini Scientific Corp.

The Model SP-S-1000 has three flow meters with integral valves for controlling and monitoring arc gas, powder gas and cover gas flow. A variac controls the power input to the plasma gun and an ammeter and voltmeter monitor these conditions. A solenoid valve in the powder feed line enables interruption of powder flow at any time during the spray operation and subsequent initiation of powder flow at present conditions.

The unit weighs less than 20 lbs.

Circle No. 182 on Subscriber Service Card

Spectrometer

A general-purpose spectrometer, designed to provide information on the environment of hydrogen nuclei in complex chemical compounds, is available from Analytical Instrument Div. of Varian Associates.

The A-60A NMR system is based on the A-60 spectrometer. Special features include a built-in heat exchanger and the addition of three slow-sweep speeds: 1,000, 2,500 and 5,000 seconds. Tests have shown that the unit will operate reliably to produce usable spectra at ambient temperatures from 15° to 35°C, the firm said. The magnet system can achieve 14,000 gauss with minimum size and weight.

Circle No. 183 on Subscriber Service Card

Flashtube

A high-energy flashtube, the CR3-601, has been developed by Xenon, Inc. The unit has spectral characteristics closely approximating nautral sunlight and is designed for pulsed laser applications where water cooling is a marginal necessity.

The device has a 600 joules/pulse input capacity with a 3-in. gap and output characteristics identical to the conventional C3-601. The concentric arc electrodes localize the arc in the center of the quartz envelope and guard against quartz devitrification at electrode contacts.

Circle No. 184 on Subscriber Service Card

Argon Laser

A multiwatt CW argon laser that provides output in a single transverse mode in the range between 4,579 and 5,145 Angstroms has been developed by h nu systems, inc.

The Model 3410P provides approximately 0.25 watt of power in each of the two strongest lines at 4,880 and 5,145 Å. The laser can be operated on single lines and can be provided with line selection.

The unit includes a precision cavity with 2-in. micrometers. The 2-micron resolution of the micrometers permits tuning of the cavity length to a few kilocycles per second out of 6 x 10^{14} cps. The water-cooled plasma tube is powered by a 20-kw power source.

Circle No. 185 on Subscriber Service Card

Fluid Heater

Portability and a heating capability to 1,500°F are features of a high-temperature, high-pressure fluid heater developed by Palomar Industries, Inc.

The unit is an indirect heat exchanger with application in hot-gas purging of liquid-oxygen storage tanks and containers, primary and booster heating of heat transfer fluids in industrial processing, and superheating of steam.

The heater features a stainless steel, closely wound coil cast with heating elements in high-conductivity metals. Overall cabinet dimensions are 18 x 18 x 24 in. The unit handles pressures to 500 psi.

Circle No. 186 on Subscriber Service Card

Portable X-Ray

A lightweight Xray unit, featuring an end-grounded beryllium window tube designed for use in the aircraft, automotive, marine and construction industries, is being marketed by Sperry Products Div. of Automatic Industries.

SPERRY X-RAY

The SPX-160's transformer tube head weighs less than 26 lbs. and can produce 160-kv and 5-ma on a continuous duty basis. Its developers say that its size (less than 7 in. in diameter and 30 in. long) and end-grounded configuration permit maximum positioning ease in formerly inaccessible areas.

Circle No. 187 on Subscriber Service Card

Vacuum Relay

A high-voltage vacuum relay, capable of switching up to 25 kv in air, is now available from High Vacuum Electronics.

The Model H-17 SPDT has a continuous current carrying capacity of 25 amps and maximum operating time of 25 millisecs. Contact resistance is 0.012 ohm, maximum; coil voltage is 26.5v dc. It is available with flange mounting or threaded base.

Circle No. 188 on Subscriber Service Card

High-Vacuum Evaporators

A line of high-vacuum evaporators with an ultimate vacuum capability of 1 x 10^{-8} torr in 24 hours is available from Westinghouse Electric Corp.'s Scientific Equipment Dept.

The Model PS124 is able to pump down to 1 x 10^{-7} torr in three minutes. It basically consists of a 6-in. stainless steel diffusion pump with a speed of 1,800 liters per second, a mechanical pump and necessary valving and controls. Manual evaporators can be constructed by adding a 20-in. base plate with eleven 1.25-in. ports and an 18-in. bell jar, feed-throughs, a 2-kva power supply and an ion gauge.

Safety devices include a thermal switch to trip a breaker in case of overheating and a limit switch on the bell jar to prevent operation of the glow discharge when the jar is raised. Interlocked controls prevent opening of incompatible valves at the same time. On power failure, all four valves close.

Circle No. 189 on Subscriber Service Card

PROVEN RELIABILITY—
SOLID-STATE POWER INVERTERS
over 260,000 logged hours— voltage-regulated, frequency-controlled, for missile, telemeter, ground-support, 135°C all-silicon units available now—

INTERELECTRONICS VOLTAGE REGULATED INTERVERTER POWER SUPPLY

Interelectronics all-silicon thyratron-like gating elements and cubic-grain toroidal magnetic components convert DC to any desired number of AC or DC outputs from 1 to 10,000 watts.

Ultra-reliable in operation (over 260,000 logged hours), no moving parts, unharmed by shorting output or reversing input polarity. Wide input range (18 to 32 volts DC), high conversion efficiency (to 92%, including voltage regulation by Interelectronics patented reflex high-efficiency magnetic amplifier circuitry).

Light weight (to 6 watts/oz.), compact (to 8 watts/cu. in.), low ripple (to 0.01 mv. p-p), excellent voltage regulation (to 0.1%), precise frequency control (to 0.2% with Interelectronics extreme environment magnetostrictive standards or to 0.0001% with fork or piezoelectric standards).

Complies with MIL specs. for shock (100G 11 mlsc.), acceleration (100G 15 min.), vibration (100G 5 to 5,000 cps.), temperature (to 150 degrees C), RF noise (I-26600).

AC single and polyphase units supply sine waveform output (to 2% harmonics), will deliver up to ten times rated line current into a short circuit or actuate MIL type magnetic circuit breakers or fuses, will start gyros and motors with starting current surges up to ten times normal operating line current.

Now in use in major missiles, powering telemeter transmitters, radar beacons, electronic equipment. Single and polyphase units now power airborne and marine missile gyros, synchros, servos, magnetic amplifiers.

Interelectronics—first and most experienced in the solid-state power supply field produces its own all-silicon solid-state gating elements, all high flux density magnetic components, high temperature ultra-reliable film capacitors and components, has complete facilities and know how —has designed and delivered more working KVA than any other firm!

For complete engineering data, write Interelectronics today, or call 914 ELmwood 8-8000, in Congers, New York.

INTERELECTRONICS CORPORATION
650 U.S. Route 303, Congers, N.Y. 10920

Circle No. 70 on Subscriber Service Card

Coating Agent

A coating system which combines Teflon with a self-cure inorganic zinc silicate has been announced by Industrial Metal Protectives, Inc.

Zincilate 103 offers the lubricity of Teflon and the resistance to corrosion, lack of toxic fumes, flash point and fire hazard of zinc silicate, the firm says. The coating will dry to positive hardness within one hour at temperatures ranging from 40° to 140°F and humidity up to 95%. It can be applied over white or grey metal. Four gallons will cover 1,000 sq. ft. at an average thickness of 3 to 5 mils, the firm guarantees. Any additional coating needed will be supplied free.

If a topcoat is desired, the firm offers Zincilate 105, an inorganic, nonflammable coating also containing Teflon. It is available in six colors.

Both coatings are said to meet military specifications for flexibility, adhesion, hardness, petroleum and solvent resistance, galvanic protection and application on wet blasted surface.

Circle No. 190 on Subscriber Service Card

Digital Clock

Parabam, Inc., is marketing a solid-state count down/count up clock, available in minute, tenth-minute or second resolution. It provides maximum count of up to 6 decades in any combination of sign, hours, minutes, tenth-minutes or seconds.

Time is displayed on a single plane, in-line, lampback with 1-in. high numerals. For observation at remote stations, up to 40 displays can be operated in absolute synchronism.

Circle No. 191 on Subscriber Service Card

Potentiometer

A 2-in.-dia. servo-mount precision potentiometer has been announced by Trimpot Div. of Bourns, Inc.

The Model 3450 is a 10-turn unit with a resistance range of 100 to 1 megohms and a linearity of ±0.15%. It meets MIL-R-12934C specifications. Other specifications include: resistance tolerance, ±3% std.; resolution, 0.024 to 0.004; operating temperature range, −65° to 125°C; power rating, 5 watts at 70°C; and ganging up to 5 cups.

Circle No. 192 on Subscriber Service Card

Telemetry Transmitter

A two-watt telemetry transmitter that isolates power, signal and chassis grounds by 100 megohms minimum is available from International Electronic Research Corp.

The Model 447 is a solid-state FM unit built to NASA specification 50M60230. It is crystal-controlled within ±0.005% and has a telemetry band of 215 to 260 mc. Temperature range is −20° to 85°C.

Other characteristics include an input power of 28v dc ±3v at 1.1 amps maximum. Frequency response is within ±1.5 db from dc to 300 kc; deviation sensitivity is 125 kc per volt RMS. The unit features a linear deviation of ±1.0% for ±125 kc deviation. Maximum deviation capability is ±250 kc. Input impedance is 20 k ohms, shunted by less than 15 pf. Incidental noise is 1,000 cps maximum.

Circle No. 193 on Subscriber Service Card

Silicone Fluid

A modified dimethyl silicone fluid, said to remain stable up to twice as long at 550°F as specialized methyl-phenyl silicone fluids, is being marketed by General Electric Co.'s Silicone Products Dept.

The material, SF-1093, is available in five standard viscosities ranging from 50 to 10,000 centistokes. Typical gel time of the series ranges up to 700 hours at 550°F to 2,500 hours at 450°F in an oxidative atmosphere.

Circle No. 194 on Subscriber Service Card

RF Transistor

A transistor capable of developing 50 watts RF power at 150 mc has been developed by ITT's Semiconductor Div., Shockley Laboratory.

The Model 3TE220 is designed for output use in high-gain Class B and C RF amplifiers and has the emitter electrically connected to the case to permit high-gain performance. Lower feedback between input and output is also made possible by this feature, the company said.

Circle No. 195 on Subscriber Service Card

Frequency Standard

A fully synthesized atomic frequency standard, miniaturized for such applications as airborne navigation, manned orbiting space laboratories and space tracking systems, is being produced by Varian Associates.

The R-20 rubidium frequency standard measures 0.4 cu. ft. and weighs 20 lbs. It consists primarily of a servo system in which a crystal oscillator is locked to the electron hyperfine transition frequency found in the rubidium atom. This invariant atomic frequency provides a long-term stability of 5 x 10^{-11}. Other specifications include an accuracy of ±1 x 10^{-10} and output frequencies of 5 mc, 1 mc and 100 kc.

Circle No. 196 on Subscriber Service Card

—contracts and procurements—

AWARDS

AIR FORCE

$5,538,283—**Douglas Aircraft Co., Inc.,** Santa Monica, Calif., for launch support services at Vandenberg AFB, Calif.

$4,852,370—**Sperry Rand Corp.,** Philadelphia, to make electronic data processing equipment.

$4,700,000—**Bogue Electric Manufacturing Co.,** New York City, for production of mobile power units for ground use which will supply power for radar and missile sites and can be used by combat units.

$4,185,243—**International Business Machines Corp.,** Poughkeepsie, N.Y., for electronic data processing equipment.

$3,449,400—**Thiokol Chemical Corp.,** Wasatch Div., Brigham City, Utah, for *Genie* rocket motors.

$2,500,000—**Textron, Inc.,** Bell Aerospace Corp., Niagara Falls, N.Y., for work on prototype rocket engines.

$2,326,000—**General Electric Co.,** Philadelphia, for continued development and testing of unspecified space vehicles.

$1,955,622—**Lear-Siegler, Inc.,** Grand Rapids, Mich., for gyroscopes.

$1,700,000—**International Telephone and Telegraph Corp.,** Federal Laboratories, Nutley, N.J., for Loran-C long-range navigation receivers.

$1,550,000—**Hallicrafters Co.,** Chicago, for work on a classified contract.

$1,477,794—**General Electric Co.,** Philadelphia, for research and development work on Mark 12 missile re-entry systems.

$1,200,000—**Philco Corp.,** Willow Grove, Pa., for continued work on a combat operations center computer.

$1,000,768—**Douglas Aircraft Co., Inc.,** Santa Monica, Calif., for launch support services for space programs at Vandenberg AFB, Calif.

$1,000,000—**Royal Industries, Inc.,** Royal Jet Div., Pasadena, Calif., for fire bombs to be used in COIN-type operations.

$192,585—**Hughes Aircraft Co.,** Hughes Research Laboratories, Malibu, Calif., for development of a prototype high-response attitude control rocket engine test stand system.

$190,000—**Itek Corp.,** Lexington, Mass., for a special optics fabrication program.

$97,600—**Martin Co.,** Baltimore, for investigation of ablator attachment analysis and methods.

$75,207—**North American Aviation, Inc.,** Downey, Calif., for 10-month study for orbit analysis of communications satellite.

$59,295—**General Dynamics Corp.,** Astronautics Div., San Diego, Calif., for design, fabrication and experimental verification of cryogenic tankage applicable to manned aerospace systems.

General Telephone and Electronics Corp., Sylvania Electric Products, Inc., New York City, for a study in the use of simultaneous video and audio commands in complex military weapons-control display systems (amount not disclosed).

ARMY

$1,161,000—**Hughes Aircraft Co.,** Fullerton, Calif., for engineering and design for *AADS-70* system.

$46,981—**Sperry Rand Corp.,** Salt Lake City, for *Sergeant* missile system training equipment.

$34,557—**International Energy Conversion, Inc.,** Garland, Tex., for micro-thermoelectric coolers for the *Redeye* missile system.

NAVY

$2,342,243—**Lockheed Aircraft Corp.**, Sunnyvale, Calif., exploratory research on *Poseidon*.

$1,592,298—**Collins Radio Co.**, Cedar Rapids, Iowa, for work on communications equipment.

$1,560,471—**Technical Materiel Corp.**, Mamaroneck, N.Y., for radio transmitters.

$1,033,064—**General Dynamics Corp.**, Pomona, Calif., for research and development work on *Terrier* and *Tartar*.

$660,140—**Vitro Corp. of America**, Vitro Laboratories, Silver Spring, Md., for engineering services for development and improvement of weapon system installations.

$97,693—**Stanford Research Institute**, Menlo Park, Calif., modification for research in area of synthesis of high energy compounds for rocket propellants.

$89,996—**Hughes Aircraft Co.**, Fullerton, Calif., for special study of advanced surface missile system.

$69,354—**Lockheed Missiles and Space Co.**, Sunnyvale, Calif., for technical services for *Polaris* re-entry system.

$61,900—**Raff Analytical Study Associates, Inc.**, Silver Spring, Md., for study of the technical and management history of the *Typhon* weapon system.

$46,592—**General Precision, Inc.**, Aerospace Group, Little Falls, N.J., for study on the application of stellar inertial guidance to sea-deployed ballistic missiles.

$35,802—**McDonnell Aircraft Corp.**, St. Louis, Mo., for continuation of research and development toward conceptual flutter analysis techniques applicable to guided missile configurations.

NASA

$3,000,000—**Sperry Rand Corp.**, Sperry Gyroscope Co., Great Neck, N.Y., to provide support services for Goddard Space Flight Center.

$1,300,000—**Scientific Data Systems**, Santa Monica, Calif., for three DEE-6 digital events evaluators to be used at Huntsville and at Cape Kennedy to perform automatic checkouts on *Saturn* rocket stages.

$1,198,923—**American Machine and Foundry Co.**, New York City, for manufacturing, assembling and testing supplies and components for the *Saturn V* tail service mast.

$160,055—**Systems Engineering Laboratories, Inc.**, Ft. Lauderdale, Fla., for a vehicle instrumentation simulator.

$91,432—**Midwest Research Institute**, Kansas City, Mo., for thermal analysis study.

$32,650—**Ramsey-Kantz, Inc.**, Orange, Tex., for fabrication of *Gemini* tipping cradles.

INDUSTRY

$2,400,000—**American Machine and Foundry Co.**, Baird Div., New York City, from **U.S. Steel Corp.**, Pittsburgh, for fabrication of parts for missile facilities.

$1,200,000—**United Aircraft Corp.**, Hamilton Standard Div., Windsor Locks, Conn., from **Grumman Aircraft Engineering Corp.**, Bethpage, N.Y., to develop and manufacture static inverters for LEM.

$600,000—**Swedlow Inc.**, Garden Grove, Calif., from **Aerojet-General Corp.**, Sacramento, Calif., for an undisclosed number of reinforced plastic nozzle extensions for the second stage solid propellant rocket motor of *Minuteman II*.

$350,000—**Electrada Corp.**, Culver City, Calif., from **Textron Inc.**, Bell Aerosystems Co., Buffalo, for work on the *Apollo* lunar program.

$300,000—**Aeroflex Laboratories, Inc.**, Plainview, N.Y., from **Farrand Optical Co., Inc.**, Bronx, N.Y., for design and development of a lunar ascent and descent landing simulator.

$72,789—**Conic Corp.**, San Diego, from **General Dynamics Corp.**, Convair Div., San Diego, for the production of high reliability telemetry transmitters for use in the NASA *Centaur* program.

Thiokol Chemical Corp., Wasatch Div., Brigham City, Utah, from **Douglas Aircraft Co.**, Santa Monica, Calif., to test components for the *Saturn* S-4B stage (amount not disclosed).

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Negotiations will be conducted with General Electric Co., Pleasanton, Calif., for expansion of work currently being performed on the development of fuel-clad emitters. Small business firms or others interested in subcontracting opportunities should make direct contact with GE.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Virginia

RFP-L-5473 due April 19, 1965, for research on refurbishable thermal protection panel concept for lifting body entry vehicles.

Bureau of Naval Weapons
Department of the Navy
Washington, D.C. 20360

A quotation will be solicited from Radio Corporation of America, Defense Electronics Products, for a research and development program to develop design changes on *Talos*. For information only; RFP not available.

U.S. Army Missile Command
Redstone Arsenal, Alabama

A contract to provide technical assistance and specialized engineering support services in solid propellantry will be negotiated with Rohm and Haas Co. Small business firms or others interested in subcontracting opportunities should make direct contact with Rohm and Haas.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

Research program on radio astronomy and plasma for *Apollo* extension systems, RFQ DCN 1-5-21-00009, due date April 16, 1965, is sought by Marshall Space Flight Center. Period of performance shall be ten months from date of any resultant contract.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

Research and development of an improved fiber optics bundle methods of manufacture and storage of continuous filaxent optical quality glass fibers sought by MSFC. RFQ 1-5-41-51191 due date April 22, 1965.

NASA Manned Spacecraft Center
General Research Procurement Branch
2101 Webster Seabrook Road
Houston, Texas 77058

Evaluation of undirectional thermal radiation properties of materials sought by MSC. RFP BG 751-68-5-676P due date April 19, 1965.

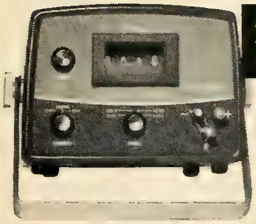
U.S. Army Missile Command
Procurement and Production Directorate
Procurement Operations Office
Attn: AMSMI-IWB
Redstone Arsenal, Alabama 35809

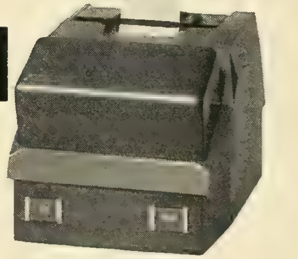
Philco Corporation has received a contract to design, develop, fabricate and test the *Chaparral* Air Defense System. Small business firms or *others* interested in subcontracting opportunities in connection with the described procurement should make direct contact with Philco.

National Aeronautics and Space Administration
Manned Space Flight Branch
Contracts Division
Washington, D.C.

Negotiations are anticipated with Lockheed Missiles and Space Company for the extension of a study to develop a conceptual design and optimization of measurement devices for biomedical and human factors testing for orbital research laboratory concepts. For information only; RFP not available.

NEW
DIGITEC DIGITAL
VOLTMETER & PRINTER
$1215
complete system





Model 201MN
- 0.1% or 0.2% FS Certified Accuracy.
- Readings from 0.1 MV to 1000 V DC.
- Floating or Grounded Input.
- Reliable Silicon Transistor Circuit.
- Individually Calibrated & Certified.
- BCD 1-2-4-8 Coded Output in Parallel Form.

Model 600
- BCD 1-2-4-8 Parallel Input (+6 V or +12 V).
- Prints 2 Banks of 4 Columns.
- Automatic Negative Sign Print.
- 48 Line/Minute Print Rate.
- Uses Standard 2¼" Paper Tape.
- Remotely "Programmable".

ALSO AVAILABLE
- Coded Output on All DigiTec Instruments.
- Time, Identification and Serializing Accessories.
- Printer to Provide Addition and Subtraction Functions.

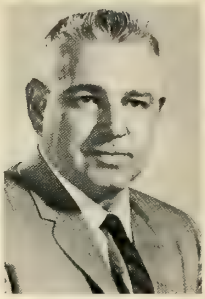
JUST PUBLISHED
New 32-page color catalog!
Write for your copy.

UNITED SYSTEMS CORPORATION
918 Woodley Road, Dayton 3, Ohio (513) 254-3567
Stocking Representatives throughout the World.

Circle No. 71 on Subscriber Service Card

names in the news

HAYES


REEDER

McTIGUE

PEARCE

BLACK

Monson H. Hayes, Jr.: Appointed president of Consolidated Systems Corp., a subsidiary of Scientific Data Systems. He was formerly vice president and general manager of the Electronics Div. of Whittaker Corp.

Samuel S. Reeder: Named director of Martin Company's Washington regional office. He comes from the Baltimore Div. where he was director of sales and requirements for the space programs department.

Robert T. McTigue: Elected chairman of the board of Hart Manufacturing Co., a subsidiary of Oak Electro/Netics Corp. He was formerly president and will continue as chief executive officer of the company. Succeeding him as president is **Ralph A. Dickison,** who was formerly vice president and general manager.

Paul F. Pearce: Named a vice president and general manager of the Military Systems Div. of Lockheed Electronics Co., a division of Lockheed Aircraft Corp. **J. G. Napoles** has been appointed to the new position of Administrative Director.

Walter E. Black: Became executive vice president of Aeromarine Electronics, Inc. He will be responsible for production, engineering, finance and quality control for the company's electronic instruments and components for aerospace, industrial and marine use.

Robert H. Cranshaw: Appointed assistant vice president and general manager of the Military Div. of General Electronic Laboratories, Inc. He was formerly with Electro-Mechanical Research, Inc.

Ross E. Hupp: Appointed chief engineer of Stellarmetrics, Inc., aerospace communications and instrumentation manufacturer. He will supervise all engineering on both ground and airborne communications systems and equipment.

Peter J. Mettam: Promoted to principal scientist of Booz, Allen Applied Research Inc.'s Research and Analysis division. Also promoted was **Sidney Berger** to princpal engineer.

Robert R. Radula: Will head the 1965 annual national meeting of the Society of American Value Engineers. Working with him will be **Frederick S. Sherwin,** past chairman of the Electronic Industries Association's Value Engineering Committee. Both men are with Raytheon Co. as value engineers.

Jesse M. Shaver: Elected executive vice president of American Air Filter Co. He is also a director of the company.

Carl A. Herold: Elected to the board of directors at Breeze Corporations, Inc. He is treasurer and assistant secretary for the company. Also elected to the board was **Mortimer Katz,** an attorney.

Michael R. Rossi, Jr.: Promoted to general manager of the Electronics Division-Connecticut of Electronic Specialty Co. He was previously assistant general manager.

John S. Munn: Appointed manager of aerospace market planning for Vickers Inc., a division of Sperry Rand Corp.

Roger J. Crowley, Jr.: Elected to the board of directors at Computer Control Company, Inc. He is director of the New Hampshire Aeronautics Commission and a retired Navy captain.

S. L. Levy: Elected chairman of the Microelectronics subdivision of the Electronic Industries Assn. He is manager of integrated circuits product marketing for Motorola Semiconductor Products.

Lawrence H. Bannister: Joined EPSCO, Inc. as chief engineer, airborne systems. He will be responsible for airborne, spaceborne and missile electronics involving instrumentation, telemetry, data processing and command links.

Wilbert F. Hamel: Appointed vice president of finance at Mepco, Inc., manufacturer of precision devices for the electronics and aerospace industries. He was formerly controller.

Orrin R. Bowland: Appointed director of defense systems operations of Lear Siegler, Inc. He will be responsible for management and coordination of programs utilizing the multi-divisional capabilities of LSI.

Dr. Akira Okaya: Joined the staff of Electro-Optical Systems, Inc., a subsidiary of Xerox Corp., as manager of the physical optics research section in the company's quantum physics division. He will be in charge of research in gas lasers, scanners and modulators.

Dr. Donald Drukey: Appointed manager of the research and technology division of System Development Corp. He will continue to serve as director of the ARPA project, involving studies relating information processing to the needs of command and control.

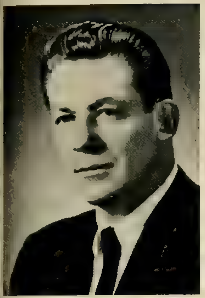
Ling-Temco-Vought, Inc. has named the following persons to top executive positions in its subsidiaries: **Samuel F. Downer,** vice president-finance of LTV Aerospace Corp.; **Carl Bentley** and **D. L. Hearn,** vice presidents of LTV Electrosystems, Inc.

Dr. W. Crawford Dunlap: Elected chairman of the board of directors for the Northeast Electronics Research and Engineering Meeting (NEREM), Nov. 3-5, 1965. He is assistant director for components technology research at NASA's Electronics Research Center. Also elected was **Dr. Arthur McCoubrey,** manager of quantum electronic devices at Varian Associates, to the office of chairman of the general committee for NEREM-65.

Arthur W. Murphy: Appointed a member of the New York State Atomic and Space Development Authority. He is professor of law at Columbia University Law School and has recently served on an advisory committee to the U.S. Atomic Energy Commission on the reorganization of the commission.

Robert T. Davis: Elected vice president of marketing at Varian Associates. He is currently on leave from Stanford University where he is a professor of marketing in the graduate school of business.

Dr. M. Gali Sanchez: Appointed vice president in charge of inorganic and nuclear research for W. R. Grace & Company's Research Division. Newly appointed to work with him were **George E. Ashby,** to manage the nuclear research section, and **Dr. R. G. Rice,** to manage the inorganic research section.


BROOKS

JERNIGAN

LUBALIN

FRIEDMAN

FROMM

Nelson S. Brooks: Appointed vice president and general manager of the Brooks Instrument Div. of Emerson Electric Co. He was formerly vice president-manufacturing. Also advanced were **George D. Keller,** formerly chief engineer, now director of research and development, and **Thomas W. Clements,** formerly with Fairchild-Hiller, now chief engineer of Brooks.

E. D. Jernigan: Appointed manager of the new Federal Systems Div. of Industrial Nucleonics Corp. He will supervise the division's activities in rocket instrumentation, hydrogen measurements for the *Apollo* program, and similar studies.

Irwin Lubalin: Appointed president and member of the board of directors of Production Technologies, a division of Avnet, Inc. He will also continue his present duties as executive vice president of Avnet-Shaw.

Dr. Raymond Friedman: Appointed associate editor of the American Institute of Aeronautics and Astronautics Journal. He is vice president-research of Atlantic Research Corp.

Kenneth M. Fromm: Appointed technical director for research and engineering of the Honeywell Radiation Center, the research and development facility for radar, lasers, electro-optics, reconnaissance and detection devices of Honeywell Inc. He was formerly vice president and technical director of Molecular Research, Inc.

Dr. Walter C. Hourt and Ira P. Barsky: Appointed to serve as assistants to the president of Atlantic Research Corp., **M. Lee Rice.**

Dr. Robert P. Petersen: Became president of the newly-formed Entech Corp., along with **Norman Hitchman,** vice president and director in charge of the Santa Barbara division. Entech provides engineering consulting services on naval missile systems.

Robert W. Moulton: Promoted to executive vice president of Applied Physics Corp.

Joseph B. Black: Joined Hadley Co. as vice president-operations. **W. R. Brown** has been named vice president-engineering.

Dr. Julius M. Peters: Joined Auerbach Corp. as a member of the technical staff where he will be concerned with the human factors aspects of the company's systems-design work, particularly on space-related projects.

Eugene N. Shaskey: Appointed manager of advanced security system research for Sylvania Electronic Systems, a division of Sylvania Electric Products Inc. He will direct approximately 35 scientists and engineers exploring new applications for current and future electronic anti-intrusion systems.

Nobel Laureate **Dr. Peter J. W. Debye** received the fourth American Physical Society High-Polymer Prize sponsored by the Ford Motor Co. for his original research on polymer structure. **Dr. John H. Van Vleck,** professor of physics at Harvard University, received the first Irving Langmuir Award in Chemical Physics sponsored by the General Electric Foundation. The Langmuir Award will be jointly sponsored by the American Physical Society and the American Chemical Society henceforth, with each society selecting a recipient in alternate years.

James E. Sloan: Appointed to the new position of assistant general manager of Raytheon Co.'s Space and Information Systems Division.

Forrest G. Allen: Recently left Interstate Electronics Corp. to resume his former business as a consultant in the defense/space marketing field. He was formerly with the U.S. Air Force as a colonel, and was prominent in the founding of the Electronic Systems Division of AFSC.

Robert J. Harrington: Appointed a vice president of Belock Instrument Corp., designers and manufacturers of military electronic equipment.

F. K. Nichols: Appointed to the new post of director of the Washington Region for the Defense Systems Division of Bunker-Ramo Corp.

Bernard Silver: Appointed to head a newly formed limited warfare group within Atlantic Research Corp.'s propulsion and chemical systems activity.

Ralph M. Trent: Retired as president of The Pangborn Corp. to become a special consultant to its parent firm, The Carborundum Co. **James R. McConnell,** executive vice president of Pangborn, has assumed the duties of chief operating officer of the company.

Sy Golub: Named to head the new Design Div. of Claude Michael, Inc. He will be in charge of the division's effort to provide industrial firms with advanced technical capabilities in product design, state-of-the-art packaging techniques and plant layout for electronics and aerospace industries interested in meeting NASA, military and commercial specifications.

Gary Lehmann: Named executive vice president and a board member of Ehrenreich Photo-Optical Industries, the military and special products division of the parent organization, Ehrenreich Photo-Optical Industries, Inc. He is also president of Gary Lehmann, Inc., a division of Ehrenreich.

Dr. Leo Steg: Selected to receive the citation "Engineer of the Year—1965" during National Engineers' Week in February. He is manager of the Space Sciences Laboratory for General Electric Co.

R. J. Schlesinger: Elected vice president-marketing and product development of International Telephone and Telegraph Corp.'s Data and Information Systems Div. Another new appointment at ITT is **John V. Horner,** veteran Washington newsman, as manager of press relations for the Washington office. He was formerly with the (Washington) *Evening Star* for 17 years.

The International Academy of Astronautics has elected five honorary members. **Col. Yuri Gagarin,** Soviet cosmonaut; **Col. John H. Glenn, Jr.,** American astronaut; **James E. Knott,** president of the Theodore von Karman Memorial Foundation, Inc.; **Prof. Manfred Lachs,** chairman of the Legal Subcommittee of the U.N. Committee on the Peaceful Uses of Outer Space; and Guido von Pirquet, contributor of concepts such as the feasibility of space flight and the parking orbit concept, were selected. Twenty-nine other scientists and engineers were elected from Germany, Russia, the U.S. and other countries for regular and corresponding membership.

let us move with you!

Six Weeks Is Required To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, if possible, the address label from your last issue . . . include your postal ZIP number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

◆◆◆

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Paris, France—11 Rue Condorcet; TRU 15-39

—when and where—

MARCH

Pricing and Negotiating Prime and Sub-Contracts in the Defense and Aerospace Industries, sponsored by Contract Management Institute, Sheraton Motor Inn, Huntsville, Ala., March 29-April 2.

Convention of the American Society of Photogrammetry and the American Congress on Surveying and Mapping, Shoreham Hotel, Washington, D.C., March 30-April 1.

Seminar on Random Vibration, sponsored by MB Electronics, MB facility, New Haven, Conn., March 30-April 8.

Advanced Planning Briefings for Industry, sponsored by the DOD and NSIA, Conrad Hilton Hotel, Chicago, March 31-April 1.

Optical Society Meeting, Statler-Hilton Hotel, Dallas, March 31-April 2.

APRIL

IEEE Seminar on Space Vehicle Reliability, Airport Marina Hotel, Los Angeles, April 2.

Sixth Structures and Material Conference, sponsored by the AIAA, Riviera Hotel, Palm Springs, Calif., April 5-7.

International Symposium on Fission Product Release and Transport Under Accident Conditions, sponsored by the Oak Ridge National Laboratory, Oak Ridge, Tenn., April 5-7.

Symposium on Advanced Propellant Chemistry, sponsored by AIAA and ACS, Detroit, April 5-7.

Symposium on High Energy Physics, sponsored by the Institute of Physics and The Physical Society (England), Birmingham, Eng., April 5-8.

International Symposium on Techniques of Memories, sponsored by the French Society of Electronics Technicians and Radioelectricians, Paris, April 5-10.

International Nuclear Exhibition and Conference, sponsored by the Institution of Nuclear Engineers, Brighton, Eng., April 5-10.

Third Navy Microelectronics Program Conference, U.S. Naval Postgraduate School, Monterey, Calif., April 6-7.

1965 Annual Region III Meeting of IEEE, Robert E. Lee Hotel, Winston-Salem, N.C., April 6-8.

IEEE Computer Technology Conference, Thunderbird Hotel, Los Angeles, April 6-8.

Dynamics of Defense Marketing, sponsored by the National Defense Education Institute, Washington, D.C., April 6-8.

Anniversary Meeting of the Chemical Society, Glasgow, Scotland, April 7-9.

CLASSIFIED

PRODUCT DEVELOPMENT CENTER
Filament Winding
Facilities available for product development, prototype fabrication, feasibility studies and testing. Write or phone Mr. Ole Marcus, McClean-Anderson, Inc., 120 W. Melvina St., Milwaukee, Wis., 53212. Phone 414 964-2970.

AC-THE ELECTRONICS DIV. GENERAL MOTORS CORPS 38
Agency—D. P. Brother & Co.

ACCREDITED PERSONNEL 164
Agency—Metropolitan Adv. Co.

ADDISON-WESLEY PUBLISHING CO., INC. 57
Agency—L. K. Frank Co.

ADVANCED SCIENTIFIC INSTRUMENTS ... 82
Agency—Thompson Grande Adv.

AEROSPACE DIV., REINFORCED PLASTICS DEPT., RAYBESTOS-MANHATTAN, INC. 52
Agency—Gray & Rogers, Inc.

AIRESEARCH MFG. CO., THE GARRETT CORP. 155
Agency—J. Walter Thompson Co.

ALLIS-CHALMERS MFG. CO. 76
Agency—Klau-Van Pietersom-Dunlap, Inc.

AMERICAN AIR FILTER CO. 159
Agency—Zimmer, McClaskey, Lewis, Inc.

AMERICAN OPTICAL CO., SPACE DEFENSE DIV. 152
Agency—Fuller & Smith & Ross, Inc.

AMPHENOL BORG ELECTRONICS CORP., SPACE & MISSILE SYSTEMS DIV. 62
Agency-Marsteller, Inc.

AUTONETICS, A DIV. OF NORTH AMERICAN AVIATION, INC. 47
Agency—Batten, Barton, Durstine & Osborn, Inc.

AVCO RESEARCH & ADVANCED DEVELOPMENT, A DIV. OF AVCO CORP. 174
Agency—Benton & Bowles, Inc.

BASIC CARBON CORP. 9
Agency—Scheel Adv. Agency, Inc.

BEECH AIRCRAFT CORP. 2, 3
Agency—Bruce B. Brewer & Co.

BELL AEROSYSTEMS CO., A TEXTRON CO., DIV. OF BELL AEROSPACE CORP. 100
Agency—Comstock & Co

BENDIX RADIO-GOVERNMENT SALES, DIV. OF THE BENDIX CORP. 115
Agency—MacManus, John & Adams, Inc.

BERYLLIUM CORP., INC. 60, 61
Agency—Harris D. McKinney, Inc.

BLOCK ENGINEERING, INC. 30

BOEING CO., THE 137
Agency—Campbell-Ewald Co.

BOEING CO., THE, VERTOL DIV. 33
Agency—Gaynor & Ducas, Inc

BURROUGHS CORP., DEFENSE & SPACE SYSTEMS GROUP 99
Agency—Campbell-Ewald Co.

CANOGA ELECTRONICS CORP. 4
Agency—Jordan-Farrell Adv. & Marketing Services

CAPITAL FILM LABS., INC. 28
Agency—Compton Jones Assoc.

Advertisers' Index

CHANDLER EVANS CONTROL SYSTEMS DIV., COLT INDUSTRIES 44
Agency—G. F. Sweet & Co., Inc.

COMPUTING DEVICES OF CANADA LTD. 35
Agency—Ardiel Adv. Agency Ltd.

CONIC CORP. 23
Agency—Teawell, Inc.

CONTROL DATA CORP. 90
Agency—Klau-Van Pietersom-Dunlap, Inc.

COX INSTRUMENTS DIV., LYNCH CORP. 34
Agency—St. Claire Adv. Agency

CRYOVAC INC. 150
Agency—The Jay H. Maish Co.

CUBIC CORP. 92
Agency—Phillips-Ramsey, Inc.

DEFENSE ELECTRONICS, INC. 10
Agency—GLM Assoc., Inc.

DELTA AIR LINES, INC. 128
Agency—Burke Dowling Adams, Inc.

DORNE & MARGOLIN, INC. 70
Agency-Snow & Depew Adv., Inc.

DORSEY TRAILERS, SPECIAL PRODUCTS DIV., SUB. OF THE DORSEY CORP. 160
Agency—Timbes & Yeager, Inc.

DOUGLAS AIRCRAFT CO., INC. 48, 157
Agency—J. Walter Thompson Co.

EITEL MCCULLOUGH, INC. 56
Agency—Cunningham & Walsh, Inc.

EX-CELL-O CORP., FLIGHT & SPACE DIV. 97
Agency—LaRue & Cleveland, Inc.

F & M SYSTEMS CO. 119
Agency—Don L. Baxter, Inc.

FLUID DYNAMICS, INC. 162
Agency—Huntley & Hurley

GENARCO, INC. 148
Agency—Berin/Pecor, Inc.

GENERAL ELECTRIC CO., LAMP GLASS DEPT. 163
Agency—Batten, Barton, Durstine & Osborn, Inc.

GENERAL ELECTRIC CO., LAMP METALS & COMPONENTS DEPT. 146
Agency—Dix & Eaton, Inc.

GENERAL ELECTRIC CO., MISSILES & SPACE DIV., SPACECRAFT DEPT. 121
Agency—Deutsch & Shea, Inc.

GENERAL ELECTRODYNAMICS CORP. 89
Agency—Alexander, MacKenzie Adv.

B. F. GOODRICH CO., AEROSPACE & DEFENSE PRODUCTS 145
Agency—The Griswold-Eshleman Co.

GOODYEAR AEROSPACE CORP. 36, 37
Agency—Kudner Agency Inc.

GRAND BAHAMA PROPERTIES, LTD. 120
Agency—Arthur R. Mogge, Inc.

GRAPHITE PRODUCTS DIV., GREAT LAKES CARBON CORP. 31
Agency—Davis, Parson & Strohmeier, Inc.

GRUMMAN AIRCRAFT ENGINEERING CORP. 85
Agency—Newmark, Posner & Mitchell, Inc

HARSHAW CHEMICAL CO., THE 88

HAWS DRINKING FAUCET CO. 118
Agency—Pacific Adv. Staff

HERCULES POWDER CO. 122
Agency—Fuller & Smith & Ross, Inc.

HEXCEL PRODUCTS INC. 20
Agency—Lennen & Newell

HI-SHEAR CORP. 21

HONEYWELL, DENVER DIV. 87
Agency—Campbell-Mithun, Inc.

HUGHES AIRCRAFT CO. 173
Agency—Foote, Cone & Belding

INFORMATION INTERNATIONAL, INC. 28
Agency—Tech/Reps

INTERELECTRONICS CORP. 165
Agency—Mark III Adv., Ltd.

INTERNATIONAL TELEPHONE & TELEGRAPH CORP. 151
Agency—Needham, Louis & Brorby, Inc.

INTERSTATE ELECTRICS CORP. 73
Agency—Jones, Maher, Roberts

JAMES, POND & CLARK, INC. 144
Agency—Weir Adv., Inc.

JOHNSON SERVICE CO. 112
Agency-Hoffman-York, Inc.

WALTER KIDDE & CO., INC. 27
Agency—West, Weir & Bartel, Inc.

KOPPERS CO., INC. 108
Agency—VanSant, Dugdale & Co., Inc.

KORAD CORP., A SUB. OF UNION CARBIDE CORP. 69
Agency—Jordan-Farrell Adv. & Marketing Services

LEAR SIEGLER, INC., INSTRUMENT DIV. 16
Agency—Aves Adv., Inc.

LOCKHEED MISSILES & SPACE CO. 158
Agency—Hal Stebbins Inc.

LOCKHEED PROPULSION CO., DIV. OF LOCKHEED AIRCRAFT CORP. 58, 59
Agency-Hal Stebbins Inc.

MB/TREBEL, A SUB. OF MB ELECTRONICS 107
Agency—Codella & Duffus, Inc.

MARQUARDT CORP., THE 74, 75
Agency—Grant Adv., Inc.

MCDONNELL AIRCRAFT CORP. 12
Agency—John Patrick Starrs, Inc.

MECHANICAL SPECIALTIES CO. 123
Agency—Getz & Sandborg, Inc.

MELPAR, INC. 142
Agency—Arthur J. Lamb, Inc.

MICRODOT INC. 19
Agency—Jones, Maher, Roberts

MINNESOTA MINING & MFG. CO., MINCOM DIV. 127
Agency—Reach, McClinton & Co. Inc.

MITRE CORP., THE 104
Agency—The Bresnick Co., Inc.

MOTOROLA, INC., MILITARY ELECTRONICS 147
Agency—Charles Bowes Adv., Inc.

NATIONAL AIRLINES, INC. 156
Agency—Kenyon & Eckhardt, Inc.

NETWORKS ELECTRONIC CORP. 68
Agency—Allen, De St. Maurice & Scroggin, Inc.

NORTHROP CORP. 50, 51
Agency—Doyle, Dane, Bernbach, Inc.

PESCO PRODUCTS DIV., BORG-WARNER CORP. 149
Agency—Penn & Hamaker, Inc.

H. K. PORTER CO., INC., NATIONAL ELECTRIC DIV. 103
Agency—Vic Maitland & Assoc., Inc.

RAYMOND ENGINEERING LAB., INC. 29
Agency—The F. W. Prelle Co.

RAYTHEON CO. 66
Agency—Hoag & Provandie, Inc.

RAYTHEON COMPUTER 32
Agency—Jay Chiat & Assoc.

REEVES SOUNDCRAFT CORP. 129
Agency—The Wexton Co., Inc.

SCIENTIFIC-ATLANTA, INC. 124
Agency—Bohm-King Assoc.

SPACE ORDNANCE SYSTEMS, INC. 164
Agency—Lynn-Western, Inc.

SPACE TECHNOLOGY LABS., A SUB. OF THOMPSON RAMO WOOLDRIDGE INC. 6, 7
Agency—Fuller & Smith & Ross Inc.

SUNDSTRAND AVIATION, DENVER DIV. 80
Agency—Hull-Mefford, Inc.

TABER INSTRUMENT CORP. 91
Agency—Harold Warner Adv., Inc.

H. I. THOMPSON FIBER GLASS CO. 161
Agency—Getz & Sandborg, Inc.

TITANIUM METALS CORP. OF AMERICA 15
Agency—W. L. Towne Co., Inc.

UNITED AIRCRAFT CORP., HAMILTON STANDARD DIV. 24, 25
Agency—Jules L. Klein

UNITED SYSTEMS CORP. 167
Agency—Advertising & Merchandising, Inc.

UNITED TECHNOLOGY CENTER 18
Agency—Hoefer, Dieterich & Brown, Inc.

UNIVAC, DIV. OF SPERRY RAND CORP. 8
Agency—Daniel & Charles, Inc.

VICKERS INC., A DIV. OF SPERRY RAND CORP. 116
Agency—Gray & Kilgore, Inc.

VITRO CORPORATION OF AMERICA 65
Agency—Buchen Adv., Inc.

WEBBER MFG. CO., INC. 148
Agency—Rohr Adv., Inc.

WESTINGHOUSE ELECTRIC CORP., AEROSPACE DIV. 132, 133
Agency—Ketchum, MacLeod & Grove, Inc.

WHITTAKER CORP., THE, ADVANCE STRUCTURERS DIV. 79
Agency—M. B. Scott, Inc.

The Week That Was

CAPE KENNEDY

AS THIS IS WRITTEN, Astronauts Gus Grissom and John Young are in orbit, the cheers of Moscow crowds still are ringing in the ears of Cosmonauts Pavel Belyayev and Aleksei Leonov, *Ranger IX* has concluded a successful mid-course maneuver en route to the Moon, and *Mariner IV* is racing *Zond II* toward Mars.

One might say without much fear of contradiction that the space race is warming up.

Although still some distance behind the Russians, the United States, after a faultless *Titan II* liftoff, definitely is back in the race. There was more than the usual tension at the Cape as the countdown proceeded for *GT-3*. In addition to the strain associated with any manned flight was the realization that after long months of drought, the U. S. was opening a new period of manned space operations.

There was a great deal riding on the performance of *GT-3*.

The Russians already had scored a neat bit of one-upmanship with the 17-orbit, 26-hour flight of *Voskhod II*, during which Leonov stepped out into space. It was a performance still more than a year away on the U. S. schedule. Furthermore, it raised the significant question of whether it might be a step toward assembly in orbit—an indicator of the direction the Soviet lunar program might be going. If so, the Soviets may have decided to make their lunar effort with their present booster—thereby bypassing an expensive development program for a new launch vehicle.

All of this increased the tension at the Cape over the start of the manned *Gemini/Titan* series. A string of windy, cloudy days, which threatened to delay the launch, did nothing to ease things.

Tuesday, however, dawned clear, warm and calm in Florida, even as the Russian cosmonauts were receiving their acclaim in the Soviet capital.

T—135. Start stage one oxidizer surge chamber adjustment. Verify all airborne hatches and doors are secure.

As *Gemini* Control droned through a list of what the two astronauts had for breakfast, downrange weather reports indicated fair weather in the landing areas. The communications network was in a go condition around the world.

T—120. Start first guidance command test in conjunction with three-axis reference system (TARS) programmer test. Verify guidance command test complete.

From California, Jet Propulsion Laboratory relayed details of the progress of the *Ranger* mid-course maneuver then under way. Astronauts Grissom and Young concluded their short bus ride to Complex 19 for their longer ride in *Molly Brown*. Complex 19—a significant one in the *Titan* program. It was from this pad that *Titan I* made its first successful 5,000-mile flight. Now its successor was making its debut as a manned booster.

T—60. Start white room evacuation. Start TARS drift test.

The biomedical team was standing by at the forward medical center. While the astronauts were running through preflight checks in their spacecraft, Vice President Hubert Humphrey was visiting the control center.

T—35. Start lowering erector. Start range telemetry readout.

Indication of an oxidizer leak in stage one of the booster was checked out during a hold. Meanwhile, down came the erector. The count was resumed. Helicopters took their positions over the abort recovery area.

T—5. Start range telemetry recorders. Arm stage-one destruct arm switch and range safety switch to internal.

All eyes, all cameras now on the missile.

T—1. Stage-one flame bucket water pressure check. Verify flight control programmed sequence test is complete.

Liftoff.

Titan II pushed its *Gemini* payload into orbit in a flawless launch.

WHY HAVE WE GONE into such detail on the by-now-familiar routine of a manned launch at the Cape? Because there is a very definite connection between the perfection with which this complex task was carried out and the theme of this special issue. It is precisely these skills which the Department of Defense is seeking to put to work on the problems of limited warfare. Though the space race continues, so do the problems of Viet Nam. If one can hit an orbit in space with such precision, there must be an answer to the problem of hitting a tank just across a ravine.

There must be command and control techniques of value to armies in the field. There must be advanced materials available to deep-submergence vehicles. There must be sensors capable of detecting enemy troops hidden from aircraft by foilage. There must be electronic gear capable of order-of-magnitude improvements in submarine detection.

It is these problems which this issue seeks to spell out—and it is this industry from which DOD seeks the answers. There remains much to be done here on Earth as we reach for the stars—even in such a notable week as this.

William J. Coughlin

Opportunities for

Design & Development Engineers in Electronic Signal Processing

Design and development activities in the field of Electronic Signal Processing are rapidly expanding today at HUGHES Aerospace Divisions.

Development of systems utilizing advanced correlation and matched filter techniques for *High-Resolution Radar, Acoustic Detection & Classification* and *Pulse Doppler Radar* is being accelerated.

Specialists in Signal Processing, Circuit Design, Mechanical Design, Packaging Design, Performance Analysis and Project Engineering will be interested in the outstanding assignments now available.

Graduate engineers with experience in wide-band video amplifiers; high-resolution cathode ray tube circuits and applications (including ultra-linear sweep, gamma correction and dynamic focus); high-voltage power supplies; low-jitter timing circuitry; high-speed analog sampling circuitry; precision film transports; ultra-high speed film development; scan conversion systems; synthetic array radar systems; imagery recording, or similar fields—are invited to submit resumes.

For immediate consideration
please write:

Mr. Robert A. Martin
Head of Employment
HUGHES Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 35, Calif.

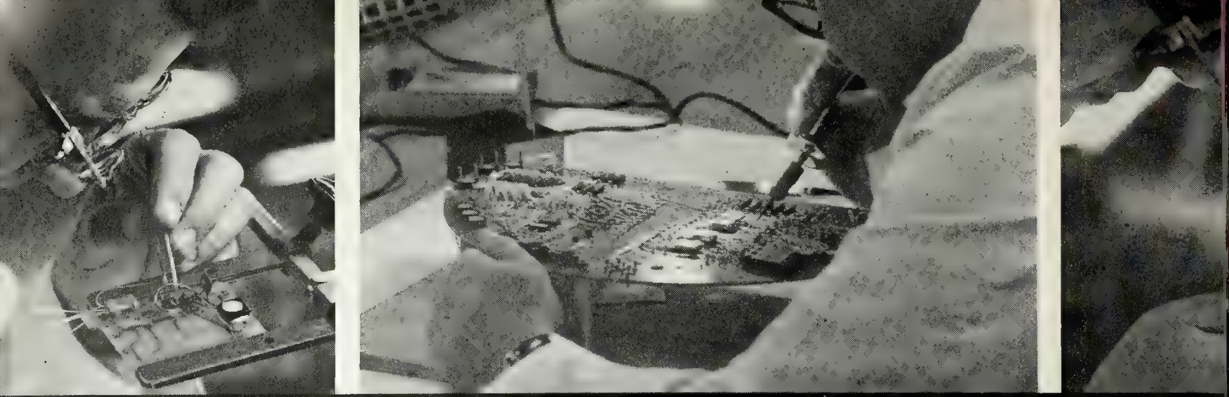
Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS

An equal opportunity employer

U. S. CITIZENSHIP REQUIRED



R&D Manufacturing:

From miniature components to manned space vehicles— Avco/RAD builds the hardware it designs. Would you expect to find a major manufacturing capability in an R&D company? At Avco/RAD, we are capable of producing anything our 1,528 scientists and engineers might dream up. Whether it's putting delicate sensors into miniature test shapes, fabricating precision arming and fuzing devices, or turning that 20-foot-diameter Apollo Command Module heat shield on the largest vertical turret lathe in the United States. We do it ourselves—right under the eyes of the engineers who designed it. At RAD, programs only start in the laboratory. We go right on through aerodynamic, thermodynamic, and environmental design and testing. We fabricate the full-scale vehicles and flight-test them. And we deliver reliable, operational systems, on time, at budgeted cost. *That's what we mean when we say: Avco/RAD is an integrated research and development organization.*

AVCO/RAD

AVCO CORPORATION/RESEARCH AND ADVANCED DEVELOPMENT DIVISION/WILMINGTON, MASSACHUSETTS

APRIL 5, 1965

missiles and rockets

HE WEEKLY OF ADVANCED TECHNOLOGY

Army Tests Aeronutronic's Shillelagh Sight

Gemini Extravehicular Capability Pu

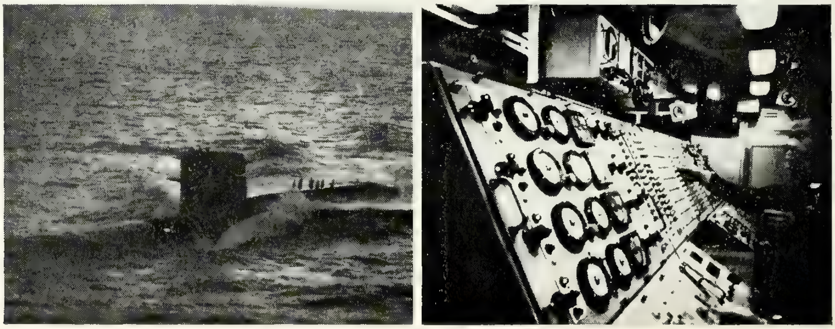
EOS Triples Efficiency of Ion Engines

Evaluation of Ranger Program—Part I . . . . .

UBLICATION

SPECIAL COMPUTER SYSTEMS PROJECT:

POLARIS



CONTROL DATA® Digital Computers add new flexibility to target selection and submarine operation

CONTROL DATA is scheduled to be *"on board" every Polaris Fleet submarine.* Polaris Fleet ballistic-missile submarines (SSBN) with Mark-80 fire control systems will utilize a new on-ship Polaris Target Data Card Computing System (PTCCS), designed, developed and supported by CONTROL DATA. Other Polaris submarines with the new, advanced fire control system, Mark 84, employ DGBC (Digital Geoballistic Computers) also supplied by CONTROL DATA — to compute data continuously down to the instant of firing. Serving the world with hardware, software, support in depth, CONTROL DATA tailors systems to the user and his methods. For details on how these special systems provide you complete performance and reliability, contact our area representative; or our Minneapolis address direct. Dept.M-45.

CONTROL DATA

CORPORATION

8100 34th AVE. SO., MPLS., MINN. 55440

Specialized computer systems from advanced technology, available today

Circle No. 1 on Subscriber Service Card

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 14 April 5, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors
Charles D. LaFond . . . . Electronics
William S. Beller . . . . Engineering

Associate Editors
Lawrence J. Curran . . . . . . Assistant Managing Editor
Heather M. David . . . . Space Medicine
Michael Getler . . . . Electronics
John F. Judge . . . . Propulsion/Materials
Robert L. Parker . . . . Copy Editor
Rex Pay . . . . Electronics
Hal Taylor . . . . NASA
James Trainor . . . . Military
Donald L. Zylstra . . . . Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach . . . . Art Director
Donald Strickland . . . . Assistant Art Director
Suzanne Montgomery . . . . Editorial Assistant
Sally Fosnight . . . . Editorial Assistant

BUREAUS
LOS ANGELES . . . . . 9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks . . . . Bureau Chief
NEW YORK . . . . 20 East 46th Street
Michael Getler
CAPE KENNEDY . . . . 507 Orange Ave.
Merritt Is., Fla.
MIDWEST . . . . 423 N. Quentin
John L. Zimmerman . . . . Wichita, Kan.
PARIS . . . . 11 Rue Condorcet
Jean-Marie Riche

EDITORIAL ADVISORY BOARD
Dr. Peter Castruccio Alexander Satin
Conrad H. Hoeppner Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton . . . . National Sales Manager
Paul B. Kinney . . . . Eastern Advertising Manager
Edwin J. Denker, Jr. . . . . Western Advertising Manager
Kenneth C. Blanchard Marketing & Research Director
John N. Carlin . . . . Director of Circulation
Paddy Nelson . . . . Circulation Promotion
R. Virgil Parker . . . . Director of Production
Barbara Wiener . . . . Advertising Services Manager

Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.

Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President . . . . Wayne W. Parrish
Senior Vice President . . . . Louis C. James
Vice President . . . . Fred S. Hunter

THE COVER

Members of Army Aviation Test Board fly simulated mission, homing in on target with new sight designed to provide blur-free image although mounted aboard vibrating aircraft. Sight shown here is designed for use with Army's Shillelagh tactical missile. See page 15.

APRIL 5 HEADLINES

Congress To Probe Aerospace Corp. Plant Financing . . . 9
Early Bird Awaits Launch This Week from Cape 9
Pentagon Pleased with Sprint Performance 12
Army Announces Launch of Two More SECOR Systems . . 12
House in Mood To Restore Space Agency Funds 13
Senate Body Opposes NASA R&D Reprogramming 13
NASA Pushing for GT-4 Extravehicular Capability 14
Air Force About To Test Inflatable Space Structure 16

SPACE PROPULSION

Ionizer Design Is Key to EOS Electrical Engine 22

MISSILE SUPPORT

Air Force Building 36,000-fps Wind Tunnel Facility . . . 24

LUNAR EXPLORATION

Ranger Results Exceed Evaluators' Expectations . . . 28

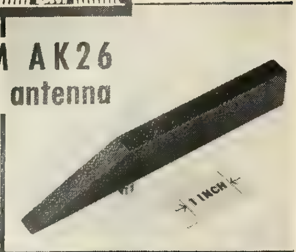
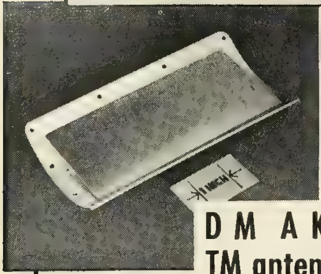
SPACE ELECTRONICS

Price Cuts To Boost Integrated Circuit Sales 32
Way Found To Reduce Laser Coherence Problems 35
Microcircuitry Seen Applicable to Oceanography 37
Autonetics System To Prevent Booster Bending 38

DEPARTMENTS

Letters 4
The Countdown 7
The Missile/Space Week® 9
Technical Countdown . . 21
The Industry Week 41
Contracts/Procurements 42
Names in the News . . . 44
When & Where 45
Editorial 46

48,000 copies this issue



DM AK26
TM antenna

DM AK6
TM antenna

Blade and Flush Telemetry Antennas

The DM AK26 low drag blade will operate in a constant 1000°F environment. The zero drag DM AK6 requires only one half inch of depth. These features are typical of those available in the complete line of TM antennas now in stock and offered for immediate delivery.

For full information contact...

dorne and margolin
INCORPORATED

29 NEW YORK AVE., WESTBURY, N. Y. 11590
9730 COZYCROFT AVE., CHATSWORTH, CALIF. 91311

20 Years of Leadership in Aircraft and Missile Antennas

N. Y. 516 ED 4-3200 • TWX 516 333-2253
CALIF. 213 DI 1-4010 • TWX 213 341-4646

letters

From Vice President/Space

To the Editor:

Just a note to thank you for the very nice editorial in MISSILES AND ROCKETS of March 8. The space program has indeed captured my imagination and I shall be devoting a good deal of my energy to it.

With my best wishes.

Hubert H. Humphrey
Washington, D.C.

Ranger Post-Mortem

To the Editor:

Reference the indirect response by NASA to the query by Lt. Col. William C. Tinsley regarding splash effect on the Moon (Letters, M/R, March 22, p. 6).

So we accept that. Now, if we are so accurate in our point of impact and truly "selected" our target *before* impact, why didn't we look at a previous impact point?

J. W. Mumma
Woodland Hills, Calif.

Presumably because more valuable information for the Apollo program was to be gained from taking a close look at a previously unapproached area of the lunar surface. Also, perhaps, because an examination of previous spacecraft impact point weeks after the impact occurred might be of limited usefulness.—Ed.

LST vs. Polaris Sub

To the Editor:

Re: use of *Polaris* submarines as cargo carriers (COUNTDOWN, March 22).

They can't be serious!

Firing cargo out of the missile launch tubes. Really! What a complicated way of doing a simple task. If the Navy wants to deliver equipment or medical supplies to underdeveloped nations without port facilities, what's wrong with the tried and true, old-fashioned, simple LST? Maybe the Navy has forgotten some of its World War II and Korean War experience. Or maybe that just isn't glamourous enough for the Aerospace Age and funding for something too prosaic would be difficult to obtain.

Milton F. Adam
Cicero, Ill.

Throttleable Engines

To the Editor:

A few comments on the Kayser/Stuttgart throttleable engine control (M/R, Jan. 25, p. 27) might include:

1. Although the increased area aspects provided by the circular, movable diaphragm may or may not be an advantage over other injector concepts, it is apparent from Figs. 1 and 2 that said diaphragms still must act as seals beneath the bolted flanges.

This is not to detract from the K/S concept, but strictly speaking, the K/S design has eliminated only shaft or pintle seals that exist in conventional variable-orifice cavitating venturis.

2. STL may have based its design "on a JPL concept," but the variable throat (via actuated, tapered pintle) venturi was described in *Rocket Applications of the Cavitating Venturi* by L. N. Randall, Figs. 6 and 7, ARS/ASME paper, June 11, 1951. Said concept probably originated earlier.

3. A complete powerplant design concept superior to both in W. S. Beller's M/R article exists. In this engine, the flow control valve, which consists of an actuator-shaft-operated, sharp-edged disc positioned in the divergent flow passage of an axial venturi, might be replaced by such as the K/S ring diaphragm device. Beyond that, such is a completely variable thrust engine consisting of a divergent nozzle with a variable, contoured throat plug whose aft section has concave taper which extends beyond the nozzle exit to provide the favorable traits of a plug nozzle. It is characterized by a) constant P_c; b) constant MR; c) variable (dw/dt); d) constant ΔP_{inj}; e) unlimited ΔF; and f) no F tail-off; g) variable A_{inj}; h) variable A_t; and i) constant A_{inj}/A_t. Resultant are: 1. Full design chamber pressure at nozzle entrance for greater efficiency; 2. Operation near zero levels with full supersonic flow in the nozzle; and 3. variation which ranges full-scale from zero to maximum design value.

R. H. Hodges
Titusville, Fla.

To which Mr. Kayser replies:

Some further remarks might be added to the highly appreciated comments by Mr. Hodges:

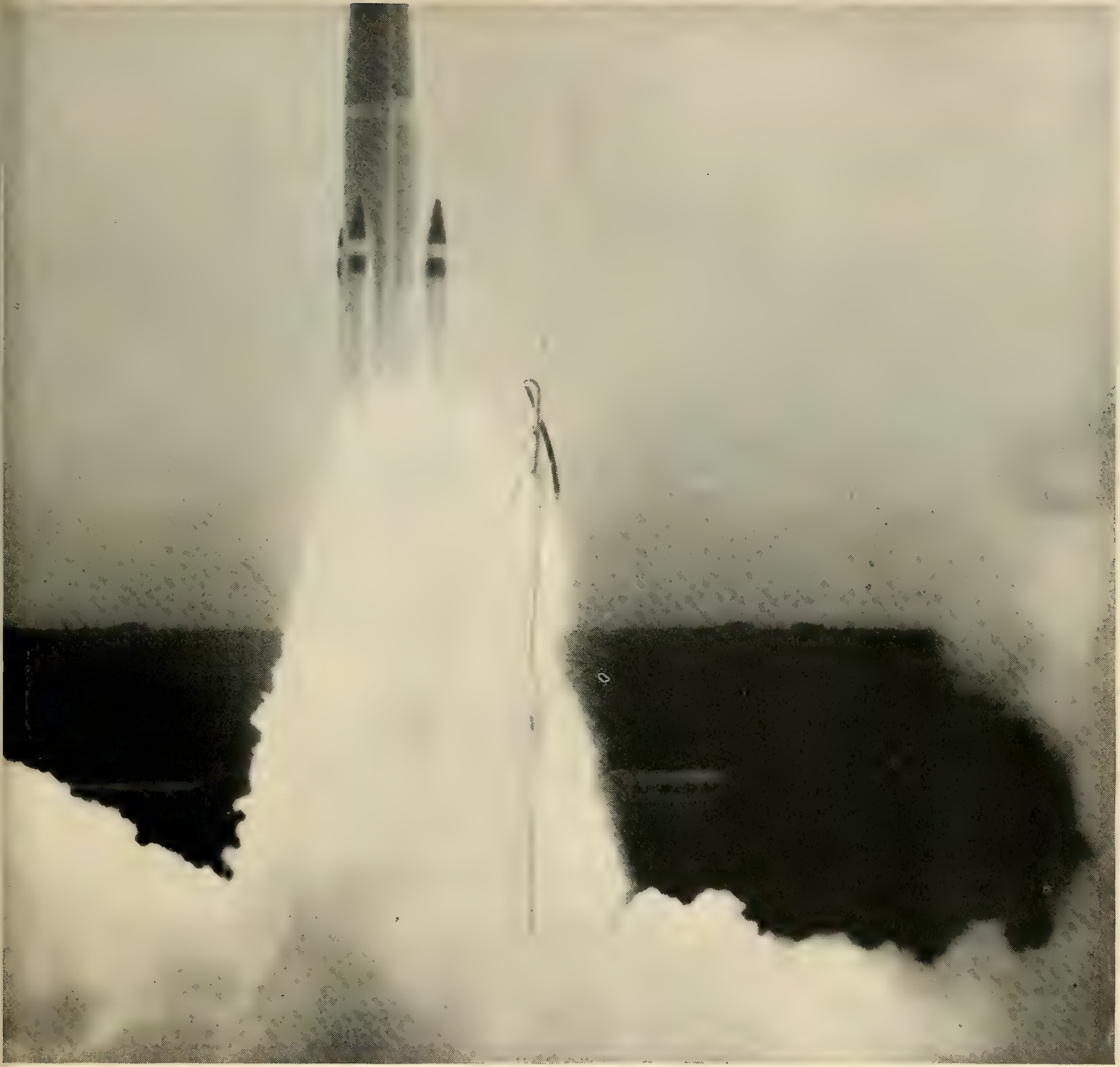
1. It is correct to state that there are still static seals in the design instead of shaft or pintle, e.g. movable seals. But those static seals may be welds without any possible leakage.

2. The H/T indication of "earlier than JPL work" in connection with axially cavitating venturis is possibly correct.

3. It is evident that the "superior" concept has the advantage of constant P_c. But the inherent cooling problems and the greater complexity of variable plug nozzle to provide constant chamber pressure could easily be incorporated in the injection concept in question, if needed. This decision depends on whether the engine is to operate under atmospheric or vacuum conditions.

Lutz T. Kayser
Institute of Technology
Stuttgart, West Germany

Circle No. 2 on Subscriber Service Card



Now Delta comes **triple-strength!**

New version of world's most reliable space booster can orbit satellites three times as heavy and five times as large as before.

The Douglas *Delta* has the world's record of 22 consecutive satellite boosts without a failure. It has orbited every non-military weather and communications satellite launched in the free world. It has been completely successful in 93% of its 29 launches.

Now Douglas and NASA (National Aeronautics and Space Administration) have improved it for even greater space achievements.

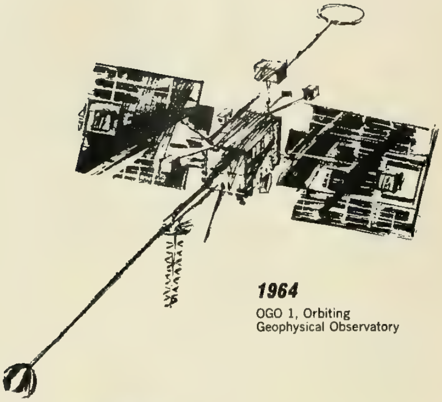
They added solid fuel rockets for more initial boost and added fuel capacity for longer firing time during second-stage boost. They also enlarged the volume of the third stage satellite container.

Result: *Improved Delta* can earth-orbit more than 1400 pounds, lunar-orbit more than 220 pounds and launch several satellites at one time.

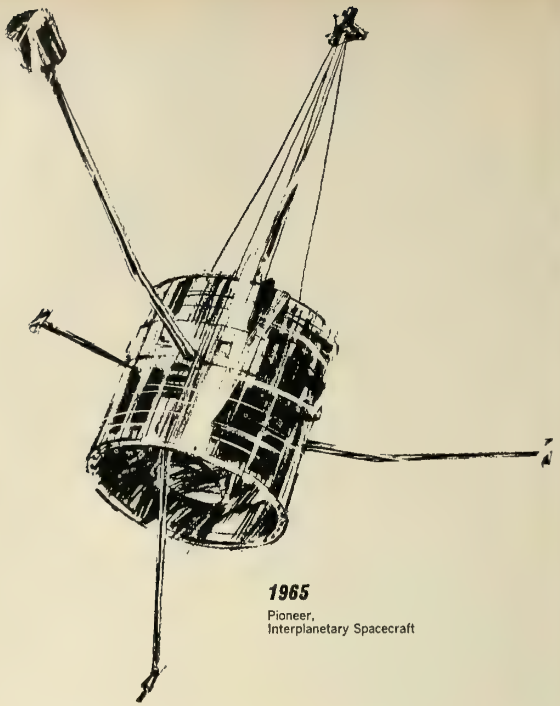
The combination of low cost and high reliability gives *Improved Delta* the highest payload-per-dollar potential of any space booster.

DOUGLAS

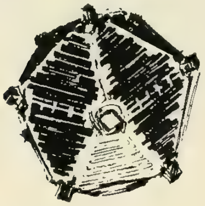
MISSILE AND SPACE SYSTEMS DIVISION



1964
OGO 1, Orbiting
Geophysical Observatory



1965
Pioneer,
Interplanetary Spacecraft



1963
Vela, Nuclear
Detection Satellites

PERSPECTIVE
TRW SPACE TECHNOLOGY LABORATORIES

A RECORD OF SPACECRAFT ACHIEVEMENT

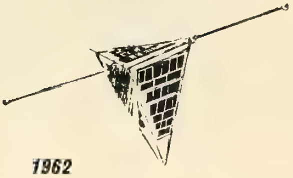
Spacecraft currently in production are OGO satellites and advanced Pioneer interplanetary spacecraft for NASA, Vela nuclear detection satellites for USAF-ARPA, and a series of Environmental Research Satellites.

PERSPECTIVE/CAREERS

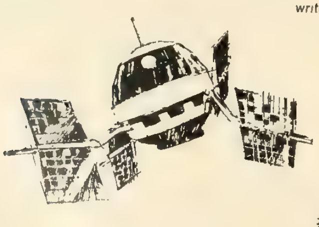
Advanced space programs and numerous other highly diversified state-of-the-art electronics and aerospace activities create immediate opportunities for engineers and scientists in: Theoretical Physics, Systems Engineering, Radar Systems, Experimental Physics, Applied Mathematics, Space Communications, Space Physics, Antennas and Microwaves, Inertial Guidance, Analog Computers, Solid State Physics, Computer Design, Telecommunications, Digital Computers, Guidance and Navigation, Electromechanical Devices, Engineering Mechanics, Applied Aerodynamics and Propulsion Systems.

*For information about TRW opportunities in Southern California and at Cape Kennedy, write TRW Professional Placement, One Space Park, Dept. **MR-4** Redondo Beach, California. TRW is an equal opportunity employer.*

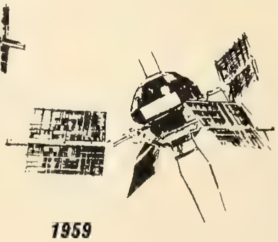
TRW SPACE TECHNOLOGY LABORATORIES
THOMPSON RAMO WOOLDRIDGE INC



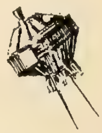
1962
ERS, Environmental
Research Satellites



1960
Pioneer V,
Interplanetary Probe



1959
Explorer VI,
Scientific Satellite



1958
Pioneer I,
Lunar Probe

The Countdown

WASHINGTON

Role Sought for Nuclear Rockets

NASA officials who favor funding of nuclear rocket programs in the fiscal '67 budget believe that such a request to Congress can be supported only if the space agency comes up with a requirement for use of the rockets in lunar resupply missions or Earth orbital operations. Manned planetary flights to Mars are so far off that nuclear rocket development based only on planetary missions could be delayed for quite a while.

Schirra May Head GT-6 Mission

Flight crew for the *Gemini-Titan 6* mission is to be named this month. Best bet as skipper on *GT-6:* Walter Schirra. Flight, now scheduled for September, is planned for seven days.

LeMay Sees Soviet Space Threat

Retired Air Force Chief of Staff Gen. Curtis LeMay warns of the military threat posed by Soviet space capabilities. He says, "It is in the arena of space that Soviet technological developments are most likely to by-pass this generation of U.S. weapon systems. Under the circumstances, then, we would do well to keep a watchful eye on the Soviet space program, and to give the benefit of all doubt to our national security and not to unsubstantiated Soviet statements of peaceful intentions."

NASA Denies Office Closing

The space agency denies a report that it is planning to close its recruiting offices in New York, Dallas and Santa Monica, Calif. NASA says it is hiring fewer people these days but plans to keep the three offices open to aid its search for top level scientists, engineers and management.

In the Merry, Merry Month of May

Watch for the next Soviet space spectacular on May 9. That's the word from Russian scientists who attended the International Institute of Electrical and Electronic Engineers convention in New York. The date commemorates the end of hostilities in Europe twenty years ago, an important milestone in Soviet history.

Aerojet To Get Phoebus Nozzle Award

NASA expects to sign a $10 million contract shortly with Aerojet-General for development of three nozzles for the Phoebus nuclear reactor. Phoebus is a graphite core reactor which will be used to power the Nerva II nuclear engine.

House Without a Master Plan

The House Space Committee wants NASA to develop a master plan for construction at all of its centers. The committee says two centers which have disdained the use of such plans, Lewis Research Center and Wallops Island, should be forced to develop them. To be included are future facilities which now may be only in the thinking stage.

Houston May Control GT-4

Decision will be made this week on whether the *Gemini 4* flight will be directed from the new Mission Control Center in Houston. A simulated run was made there prior to the *GT-3* flight last month. No major problems developed—but NASA officials say there were a lot of minor ones. Final study of the data from the run will be made before a decision is announced.

NASA Foiled in Bid to Boost Biosciences

There is strong feeling at high levels in the space agency that the U.S. is skimping its biosciences research. Associate Administrator Homer Newell told Congressional questioners that he regrets that the bioscience field lacks the kind of impetus given the physical sciences by the International Geophysical Year. He said he sought more funds for the biosciences in the agency's FY '66 budget request, but the Bureau of the Budget turned thumbs down.

INDUSTRY

GD Under Fire for Centaur

Centaur work force at General Dynamics/Astronautics has been reduced from 5,000 to 3,000 under pressure from NASA. Management of the program, however, still does not set well with some Congressmen. Rep. Joseph Karth (D.-Minn) told NASA he thinks "an inordinately bad job has been done on it by the contractor."

Economy Moves at Marquardt

Financial backers on putting pressure on the new management at Marquardt Corp. to show some substantial economies. As a result, even senior executives have found they are not immune to the axe.

Three Companies Bid on SNAP-25

Three firms have bid on development of the new SNAP-25 nuclear generator for space use—General Electric, Lockheed and RCA. SNAP-25 will be a 75-watt generator fueled with plutonium 238. Atomic Energy Commission considers it the next step in development of a standardized nuclear space power plant.

INTERNATIONAL

Martin Forms French Company

Hispano-Martin has been established in France as a joint company to market compact electric power generating systems in Europe. Parent companies are Martin Marietta Corp. and Hispano-Suiza of France. The new company will market systems using both isotopic and conventional fuels. Initial effort will concentrate on SNAP-type generators in the 5-200 watt power range for terrestrial use and on hydrocarbon-fueled generators for various government and industrial applications.

U.S. To Take Part in Paris Show

U.S. government will participate officially in the Paris Air Show June 11-21. Full-size displays of *Minuteman, Atlas, Titan II* and *Agena B* will be among the 40 Dept. of Defense missile and aircraft exhibits. There also will be 19 U.S. flight demonstrations. More than 35 firms from the U.S. are expected to exhibit at the show.

What does it take to hand-carry the American flag to the moon?

Cameras, batteries, chargers, a life support system, fuel cells, instrumentation, electronic test systems, communications, computers, decoders, navigation, guidance, tracking beacons, antennas, heat shields, parachutes, radar, rocket engines, propellants, the Manned Spacecraft Center, a launching platform, nuclear gauges, fuel tanks, sensors, the Edwards High Thrust Test Area, launch vehicles, electrical lines, a launch escape system, adapters, an optical communications system, Cape Kennedy, oxidizer tanks, pressurization systems, multicolored nylon, instant food, container packets, tooling, ground support, structures, handling and transport equipment, the George C. Marshall Space Flight Center, a blockhouse, administration, columbium metal, warehouses, security, an electronic metronome, the White Sands Missile Range, expulsion tanks, pitch controls, engines, a Lunar Excursion Module, recovery equipment, power conversion units, the Michoud Operations Plant, environmental control, valves, oxygen, diodes, water, plastics, forgings, deceleration rockets, mission simulators, engineering drawings, the Atlantic Missile Range, a test pendulum, crew couches, the Santa Susana Field Laboratory, liquid gauging equipment, honeycomb core material, aluminum alloy, hydraulic servo actuators, design reviews, the Mississippi Test Facility, cryostats, wash pads, ventilation fans, research, structural ribs, metal foil, transportation, test chambers, hydrogen, carbon steel, cement, turbopumps, the Nevada Field Laboratory, injectors, gas generators, stainless steel, O-rings, high pressure ducting, a steam generator, gimbals, microelectronics, flight suits, scientific seminars, fins, anti-slosh baffles, fairings, destruct packages, clamps, plumbing, stringers, corrugated skins, steam diffusers, a shaker table, blast shields, wind tunnels, gyros, telemetry, flight plans,

and three Astronauts
seven-and-a-half-million pounds of thrust
20,000 American companies
and the Apollo spacecraft built for NASA
by North American Aviation

Atomics International, Autonetics, Columbus, Los Angeles, Rocketdyne, Science Center, Space & Information Systems

The Missile/Space Week

Early Bird Set for April 6

Early Bird, the first commercial communications satellite, is scheduled for launch from Cape Kennedy no earlier than April 6 (M/R, March 15, p. 8).

If all goes well, by June the 85-lb. experimental/operational satellite will be sending telephone, television, teletype and photo facsimile transmissions between stations in North and South America and Europe. Comsat Corp. has been requested by the Federal Communications Commission to file proposed rates for commercial use of the satellite 30 days before service begins.

NASA will launch the satellite, built by Hughes Aircraft Co., aboard a *Thrust-Augmented Delta*. Launch window is in the early evening with the synchronous orbit to be reached about 40 hours later. Final positioning at approximately 27.5° west longitude will take several days. Initial tracking of *Early Bird* will be handled by NASA's Space Tracking and Data Acquisition Network and manned Space Flight Network. Comsat's Control Center in Washington, D.C., will assume responsibility for satellite operations after it is injected into the transfer orbit after third-stage burnout.

Aerospace Corp. Probe

Prime targets of the upcoming Congressional investigation of Aerospace Corp. are expected to be the firm's public relations program and financing of its physical plant in Los Angeles.

The House Armed Services Investigation subcommittee, headed by Rep. Porter Hardy, (D-Va.) is scheduled to begin hearings late this month after more than eight months of investigation of the non-profit firm.

Aerospace Corp. is reported to have spent more than $1 million on in-house public relations over the past four years. At the same time, reportedly, it hired a New York public relations firm, at a fee of nearly $100,000 per year, for consultation services.

The plant, admitted to be a feature of the hearings, was built and occupied by TRW Space Technology Laboratories and later sold to Aerospace Corp. when STL became an independent firm. It is reported that the subcommittee has been checking titles and charges to see if the Air Force through contracts has paid for the plant more than once.

The General Accounting Office is scheduled as the subcommittee's first witness. The Air Force and Aerospace Corp. will testify later.

Beacon Explorer Delayed

The third and final shot in the *Beacon Explorer* series was postponed March 29 when trouble developed in its geodetic beacon.

NASA says the slippage is for an indefinite period; other informed sources predict postponement of two to three weeks.

LMSC In Hospital Work

As part of its diversification program, Lockheed Missiles & Space Co. has reached agreement with a Mountain View, Calif., hospital to install a prototype information system.

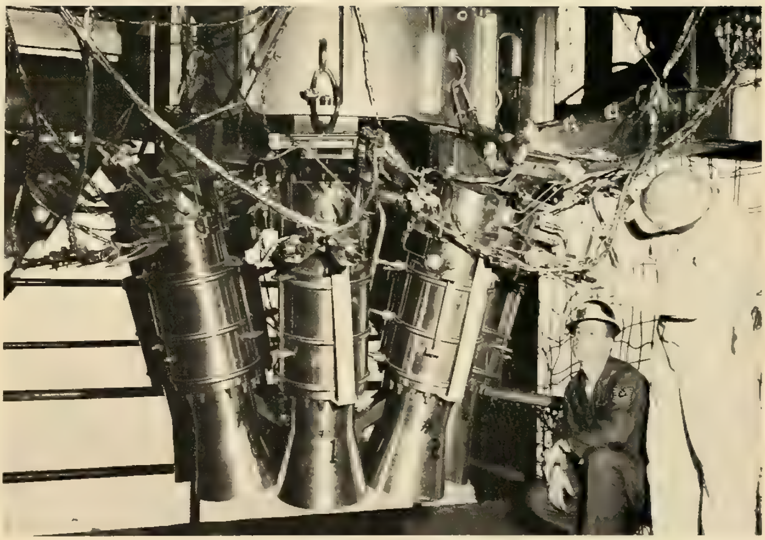
Alfred Sibley, program manager, told MISSILES AND ROCKETS that LMSC has been working on the concept of a central hospital data storage and retrieval system for 16 months and is now ready to test it in a hospital environment. Trustees of El Camino Hospital near Lockheed's Sunnyvale plant last week approved conducting the R&D program at their facility.

Sibley said the system envisions installation of Lockheed-developed input-output devices in patients' rooms, examining rooms, kitchen, laboratories, accounting and administrative offices and other hospital locations. Each would be linked to a central data bank and computer.

Poodle Funding Squeezed

Atomic Energy Commission officials are pushing hard for Congressional restoration of funds cut from their FY '66 request in the Poodle radioisotope engine program.

The agency asked for about $3.6 million, and the Bureau of the Budget slashed this to less than the cur-



Scorpio Test Fired

THIS CLUSTER of eight thrust chambers, each developing some 25,000 lbs. of thrust, were fired around a zero-length plug nozzle at the Rocket Propulsion Lab, Edwards AFB, Calif. Film cooling and advanced, simplified propellant injectors were also involved in the 200,000-lb. thrust test. All chambers were primed within 80 milliseconds of each other. A second firing verified the original test in this, the final stage of Project Scorpio. The engines promise a simple and reliable liquid propellant rocket system, singularly free of combustion instability and easily fabricated with a minimum of difficulty say AF spokesmen. The program was conceived and conducted in-house by the AF Systems Command laboratory.

STRATOS

LIFE SUPPORT SYSTEMS

APOLLO WASTE MGMT
TEST PROGRAM
FLUID COMPATIBILITY

Today Stratos can offer you full scale competence in the design, fabrication and test of systems relating to the following life support functions:

ATMOSPHERE CONTROL

- **Air Lock Compressor Systems**
- **CO$_2$ Removal Systems**
- **Humidity Control Systems**

THERMAL CONTROL

- **Space Radiators**
- **Zero Gravity Water Boiler Systems**
- **Cold Plate Systems**
- **Fluid-Fluid Heat Exchanger Systems**

WASTE MANAGEMENT

- **Urine Disposal Systems**
- **Closed Ecological Systems**

We would be pleased to detail further those program areas of interest to you. Write or call: Marketing Department, Stratos Division, Fairchild Hiller, 504 Orinoco Drive, Bay Shore, N. Y. MOhawk 5-0100 (code 516). Offices in Manhattan Beach, Calif., Seattle, Dallas, Washington, D. C. and Huntsville.

Career Bulletin: *Stratos now offers outstanding career positions to experienced mechanical engineers. Please send your resume to: Professional Staffing, in Bay Shore. An equal opportunity employer.*

FAIRCHILD HILLER

Circle No. 3 on Subscriber Service Card

rent funding—around $500,000. The Poodle engine, conceived and developed by TRW Space Technology Laboratories, is a low-thrust system using a radioisotope to heat hydrogen propellant.

An experimental model of the engine had a 100% successful run in February at the AEC's Mound Lab, Miamisburg, Ohio. During the three-day test period, the thrustor produced a specific impulse in the 650 to 700-sec. range—equal to a fuel core temperature of about 2,730°F.

The test engine produced somewhat less than 0.25 lbs. thrust, but was close to the dimensions of a flightweight model which would be 13 in. long, 4 in. wide, with a weight of 30 lbs. and a thrust of 0.25 lbs.

STL sources report that mission system studies show the thrustor promises substantial savings in future space programs such as planetary fly-bys and deep space probes. STL envisions four thrustors clustered to produce a Poodle stage.

Results of studies comparing Poodle configurations with *Centaur* stages—chosen because *Centaur* cost figures are available—indicate that for specific missions, Poodle can deliver a greater payload. Missions covered in the studies include deep space probes and communication satellites in 24-hour Earth orbit.

STL spokesmen say the greater capability of Poodle stages permits given missions with smaller boosters and even increasing the payloads in certain cases. There is some unofficial interest in a Jupiter fly-by, and Poodle could perform this mission in nine months to a year—compared with the two to three-year flight time involved in a minimum energy mission with chemical propulsion. The shorter flight time would have a substantial effect on component reliability, mission success probabilities and overall cost.

Military Science Funds Cut

The Senate version of the FY 1966 defense authorization bill as approved by the Senate Armed Services Committee carries a 5% cut in military science projects included in RDT&E requests and authorizes a total of $1,426,800,000 for missiles. Aircraft authorization in the $15,283,800,000 authorization bill totaled $5,710,700,000 and $1,549,500,000 was authorized for ships.

The Senate committee approved R&D requests totaling about $6.6 billion as compared with $6.7 billion in the House version. Overall amount approved in the Senate bill was slightly higher than the $14.8-billion House-approved version. The Senate increased the $39 million requested for advanced bomber research by adding $82 million and added $133.6 million to a $15.297-billion Navy request to add two killer-type nuclear-powered submarines.

The cut in military science requests did not affect funding of the program to safeguard the nation's defense under the nuclear test ban treaty. Neither version of the bill has yet reached the floor.

A Gathering of Titans

Three *Titans* are currently at Cape Kennedy, each ready for a different space mission.

A *Titan III-A* is scheduled for launch in mid-April from Pad 20.

The first of the *Titan III-C*'s—with solid boosters—is now due for a test launch in late May from Complex 40.

A *Titan II Gemini* launch vehicle was erected last Monday on Pad 19 and will be mated with a *Gemini* capsule due to arrive April 5.

The *Titan II* stages were brought from Baltimore by the "Pregnant Guppy," an oversized Boeing Stratocruiser, while the *Titan III* cores were ferried from Denver.

Shots of the Week

The Army on March 26 announced the recent interception near Kwajalein Island of a simulated ICBM by two *Zeus* missiles fired seconds apart. The Army says that of the *Zeus* firings conducted to date, more than 80% have been either successful or partially successful.

- Britain's *Blue Streak* rocket successfully passed its third firing test March 22 when it was launched from Woomera, Australia.
- The Air Force launched a *Thor-Agena* booster and a *Minuteman* ICBM from Vandenburg AFB, Calif., March 25. The *Thor-Agena* carried aloft a satellite of undisclosed type.
- Air Force Major Robert A. Rushworth flew the *X-15* rocket plane from Edwards AFB, Calif., March 26 on a mission to test a new radiation measuring device.
- The Army's March 26 initial launch of the *Sprint* missile was highly successful (see p. 12).
- The nuclear powered submarine USS Nathanael Greene successfully launched a *Polaris* A3 March 29 while submerged off the Florida coast near Cape Kennedy.
- The Air Force on March 30 used a *Blue Scout* booster to launch the second of five planned cosmic

radiation experiments from Cape Kennedy. Preliminary information indicated that the shot was successful and produced the data desired.

Warning Proposals Sought

Thirty-two firms have been solicited by the Air Force for proposals for a warning system for sea-launched missiles.

Apparently the work will involve suggestions for up-dating selected SAGE warning system radars to provide a capability against short-trajectory missiles. Originally $10 million was programmed for this effort, with an additional $10 million requested in the FY 1966 defense budget.

First disclosure of the program came more than a year ago, when Gen. Curtis LeMay described contemplated radar modifications as an interim step until the "primary" system, *Nike-X* is completed and placed in operation.

The 32 firms receiving RFPs included: Acoustica Associates, Avco, Bendix, Boeing, Control Data, Douglas Aircraft, General Electric, General Instrument, Goodyear Aerospace, Grumman Aircraft, Hughes Aircraft, IBM, ITT, Keltec Industries, LTV, Litton Industries, Lockheed Aircraft, Melpar, North American Aviation, Northrop, Martin, Philco, RCA, Raytheon, Sanders Associates, Space General, Sperry Gyroscope, Sylvania Electronic Systems-East, TRW Space Technology Laboratories, WECO, Westinghouse Electric, and Canadian Commercial.

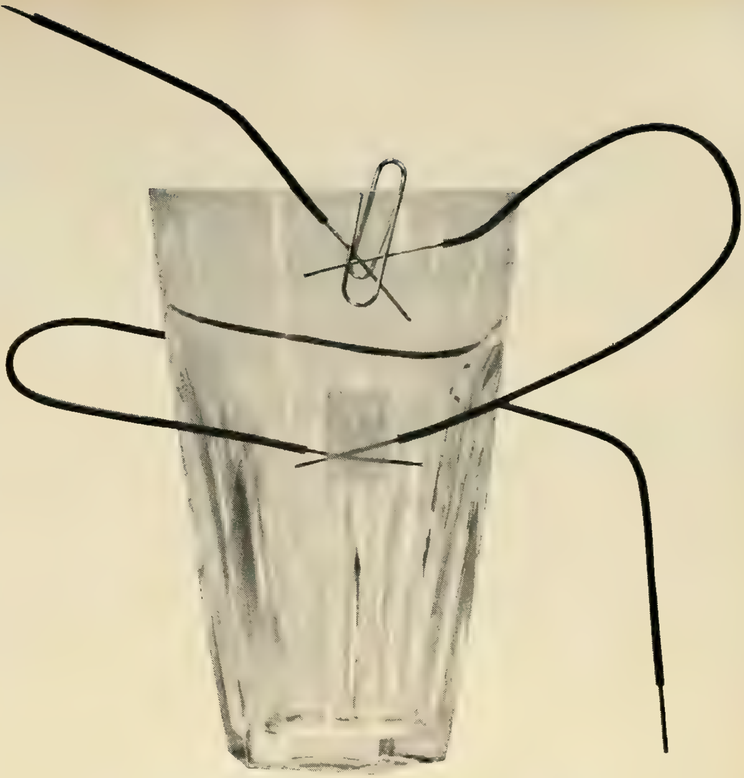
ITT Building Comsat Site

ITT Cable and Radio, Inc.-Puerto Rico, is planning to construct and operate an experimental communications satellite ground station near Caguas, P.R. The proposed station will be capable of operating with both synchronous and medium-altitude satellite systems.

The firm, a subsidiary of ITT's American Cable and Radio Corp., has filed a request for authorization with the Federal Communications Commission. On the basis of a successful test and experimental program, the firm will later request permission to operate the station commercially.

VAB Takes Form

The 57,000-ton structural steel framework for the 520-ft.-high vehicle assembly building (VAB) on Merritt Island will be topped out April 14.



A MATTER OF PRINCIPLE . . .

How can we put this unique experience to work for you? Atlas advanced the technology of miniaturized electro-explosive components and systems. Result: a wealth of research knowledge and specialized production skills.

CASE IN POINT: GLASS-TO-METAL SEALING

We developed and perfected our own facility to hermetically seal aerospace components to assure even greater reliability.

ANOTHER EXAMPLE: ELECTRON BEAM WELDING

We installed a newly-designed electron beam welder to assure higher precision of the welded construction in Atlas miniaturized electro-explosive devices and systems.

These facilities are part of a fully equipped plant with controlled environment where we also do our own thermoplastic extrusion, certified gauge calibration—all of the critical manufacturing steps that affect quality or reliability.

We can design and produce complete electro-mechanical sub-systems involving explosives problems, or we can work as a sub-contractor in specific areas of manufacturing.

Spark any ideas? Why not explore them with us in a letter? You'll get a prompt response. Or better yet, call us today.

ATLAS
CHEMICAL INDUSTRIES, INC.
Aerospace Components Division
Valley Forge, Pa. 19481
Circle No. 4 on Subscriber Service Card

All-modes test next? . . .

First Sprint Flight Gratifies DOD

ARPA's rapid-acceleration anti-missile missile tops hopes; flight omits gas-generated pre-ignition pop-up routing

THE HIGHLY SUCCESSFUL first flight test of the *Nike-X* system's *Sprint* missile late last month makes an in-sequence test of *all* modes of the missile's flight the logical next step in the testing series.

Launched from an above-the-ground site, rather than from a silo, as would be the case under operational conditions, the first *Sprint* flight omitted the gas-generated pop-up procedure designed to lift it out of its silo before ignition of the main booster motor.

Many observers now look for a second flight test to evaluate the pop-up routine as well as in-flight performance. It is possible that final-phase guidance of the missile to its target may also be tested.

Although *Sprint* is superior in rapid-acceleration performance to its *Zeus* predecessor, it is by no means the ultimate in a high-acceleration vehicle for anti-missile missions. ARPA's *HIBEX* is currently the vehicle being developed for the specific mission of hard-point defense of missile launching sites, command and control centers and other strategic locations.

The March 26 flight test of *Sprint* was described by Army spokesmen as "exceeding our fondest hopes." The 27-ft. missile rose swiftly from its surface launch pad at White Sands Missile Range, N.M., in a test of its propulsion plant and structural features.

- **"Weighing" time**—Present planning calls for the missile to be used along with the earlier *Zeus* missile in the *Nike-X* system, but not to the exclusion of the earlier intercept missile. *Sprint's* advantage over its slower-acceleration predecessor is in its ability to wait longer before being launched against its assigned target—to afford as much time as possible for a "weighing" process to take place in the Earth's atmosphere, Defense spokesmen explained.

Enemy-launched missiles normally would be accompanied by numbers of decoys in efforts to confuse *Nike-X* system radars. By waiting until the lighter decoys are impeded by the Earth's atmosphere, *Sprint* launching crews can direct their missiles against only genuine targets, since the extra weight in a genuine warhead reveals it to the radar computers in its terminal flight into the Earth's atmosphere.

Because warning systems are not a primary factor in the operation of the *Nike-X* or other proposed anti-missile-missile systems, since they are designed to operate virtually autonomously with their own integral radars, many observers are speculating on the meaning of a request for proposals for updating Sage-system radars to afford a means of detecting shorter-trajectory, slower-speed sea-launched missiles directed against the United States. (The Air Force has requested industry proposals for a feasible warning system against sea-launched missiles.) Neither the Air Force nor DOD has mentioned what type of retaliatory intercept missile or other vehicle is planned for use with a Sage system if it is up-dated as a missile warning device. ■

Army Has Three SECOR Satellites in Orbit

THE ARMY HAS ANNOUNCED that it now has three of its *SECOR* geodetic satellites orbiting the Earth. Last two launches of the orbiting geodesy vehicles occurred on March 9 and 11 respectively.

The launch of *SECOR 3* on March 9 ahead of *SECOR 2* resulted in an orbit with a 582.5-mi. apogee and a 561.3-mi. perigee, with the orbital plane inclined 70 degrees. *SECOR 2,* launched March 11, entered virtually a polar orbit after failing to deploy properly from its piggy-back container and went into an erratic orbit inclined 89.7 degree, with a 647.7-mi. apogee and a 158.3-mi. perigee.

SECOR 1, launched 14 months ago, went into an orbit closely corresponding with that of *SECOR 3.* Both satellites were described as having orbital periods of "approximately 103 min." The Army has not given the period for *SECOR 2,* presumably because of the spotty telemetry returns being received from that vehicle. The position of *SECOR 3* relative to *SECOR 1* is "50 minutes behind" it in nearly the same orbital path.

SECOR 1 has been sending radio-data back to four ground stations in the Western Pacific. Computations made recently by Army Map Service field parties indicate that this information has "located within five yards" the true position of one of the Ryukyu Islands in relation to other known points several hundred miles distant.

The first *SECOR* satellite outlasted its predicted life by a wide margin, and its powerplant operation is being carefully budgeted "to preserve the usefulness of the satellite" as long as possible. *SECOR 1* and *3* each make two passes per day over the four Pacific ground stations, "reducing the time needed to locate unknown stations Army's Map Service is attempting to pinpoint."

Cubic Corp., San Diego, Calif., developed the communications system being used in the *SECOR* system and also designed and built the ground station equipment. Development of the satellites was the responsibility of IT&T, Nutley, N.J.

Two Naval Research Laboratory satellites were orbited during the March 9 launch. Both were gravity-gradient-stabilized, one employing a three-boom system for stabilization around three axes and the other a single-boom type for two-axis stabilization.

Taking long look . . .

Committee May Restore NASA Funds

Chairman Miller eager to avoid damaging reductions; Advanced Research & Technology subcommittee votes more than was requested

by Heather M. David

THE HOUSE Science and Astronautics Committee is likely to reverse cutbacks in the Fiscal Year 1966 NASA authorization bill made in subcommittee. Full committee action is expected this week or early next week.

One of the biggest question marks is in cuts made in the *Apollo* program by the Manned Spaceflight Subcommittee. These slashes reportedly were made in the manned spaceflight portion of the budget because some members felt that too much emphasis is being given to the *Apollo* program at the expense of other research.

House space committee Chairman George P. Miller (D-Calif.) told MISSILES AND ROCKETS he would not want "to see any cut that would retard or hamper" the program and he would take a long look at the situation. He added that he did not know what action he would take until he found out the reason for the cuts in the full committee hearings.

Rep. James Fulton (R-Pa.) said he still was not sure just what the final amount of the manned spaceflight portion should be. Fulton, who has long been a proponent of more research in advanced propulsion techniques, said that he planned to examine very carefully NASA's original request to the Bureau of the Budget in the chemical propulsion study area, which falls in the Advanced Research and Technology portion of the budget.

Fulton said he was disturbed at cuts made by BOB in NASA's original request—including $5 million for the FLOX program research, $5 million for research on a high-compression hydrogen-oxygen engine, and $2.3 million for cryogenic use of hydrogen. He also expressed concern over the fact that a $1-million addition to last year's budget for solid propellant study—which Fulton was instrumental in putting through—was apparently not used by NASA. This money, he said, was to go to research on safety precautions and clustering methods for solid-propellant rockets and other such studies. He said these are still needed.

- **Advanced Research & Technology**—The subcommittee chaired by Rep. Ken Hechler (D-W. Va.) ended up with a bonus action in its handling of the $740,601,000 budget request for which it is responsible. The group increased the amount to $743,970,850.

Addition of FY 1966 funds to the three programs deleted from NASA's request by the Bureau of the Budget—SNAP 8, the 260-in. solid rocket motor, and the M-1 engine—amounted to a total of $27.2 million, which overbalanced other cuts of almost $24 million.

A total of $8 million was earmarked for SNAP 8, Hechler told M/R. However, the subcommittee added only $6 million, with the recommendation that NASA use $2 million out of other FY '66 R&D funds. This would bring SNAP 8 money to one-half that originally requested and refused by BOB. Funds for the reactor portion of the program are included in the AEC budget.

Some $15 million was alloted to the M-1 engine program, to enable continuation of component development leading to a systems test, Hechler said.

The 260-in. solid motor program was given $6.2 million, so that NASA may move into Phase II development. This would consist of a firing of a full-length motor by one of the two contractors—Aerojet-General and Thiokol—now in Phase I.

The entire $10 million requested for the Electronics Research Center was deleted by the subcommittee. Hechler, who had proposed leaving $1 million in the fund but acquiesced to the amendment to delete the whole amount, said he felt that NASA had sufficient funds available for FY '66 from previous years' authorization, and that the agency had just been unrealistic in the way it presented its request. The action also places an embargo on any construction until the entire site NASA has chosen is acquired. NASA at present is buying the property on a lot-by-lot basis.

The Antigua *Apollo* tracking station came under subcommittee scrutiny, with the result that a $1-million cut was made in a community support construction item and $200,000 for land acquisition. Hechler said that it had been found that NASA had not fully investigated the possibility of obtaining British government-owned land rather than buying private land at $5,000 an acre.

A deletion of $3,879,000 was made in the tracking and data-acquisition portion in the research and development category. Hechler said that this largely amounted to a percentage cut.

Another cut of $8,751,150 was made in the administrative operations portion of OART and tracking budget. This amounted to a 5% across-the-board reduction in the category, the total request for which amounted to $168,271,850. The only specific recommendation made in applying this reduction is that 5% must be taken in the Electronics Research Center portion, the rest being applicable to any other center in the category. ■

Senators Take Dim View Of R&D Reprogramming

SENATE Space Committee members are taking exception to the current authority which gives NASA power to reprogram as much as 2% of its R&D funds to construction. This year, this would amount to $90 million.

Space committee members have voiced an intention to either cut the amount—to perhaps as low as .5%—or make it possible for Congress to deny permission to reprogram.

As the law now stands, NASA must inform Congress 30 days before taking action, but technically cannot be stopped. However, it is unlikely that NASA would buck strong Congressional reaction and risk possible retribution in the next year's authorization.

Systems being tested . . .

Push On for Extravehicular Ability

Manned Spacecraft Center hoping for out-of-spacecraft exercise on next flight in series, which could come in less than two months

by Hal Taylor

NASA IS RUSHING development of an extravehicular capability for the *Gemini* spacecraft for use possibly as early as the upcoming *Gemini/Titan II-4* mission.

A series of tests to qualify the spacesuit began last week at the Manned Spacecraft Center's 20-ft. man-rated chamber. Three tests will be run to check the strain release zipper, the visor and the thermal quality of the suit's micrometeoroid protection.

Although officials at the space agency headquarters discount chances of making an extravehicular experiment, Manned Spacecraft Center sources are hopeful.

Other steps to implement such an experiment are under way at McDonnell Aircraft Corp's plant, where successful depressurization of the spacecraft in a test chamber has been performed.

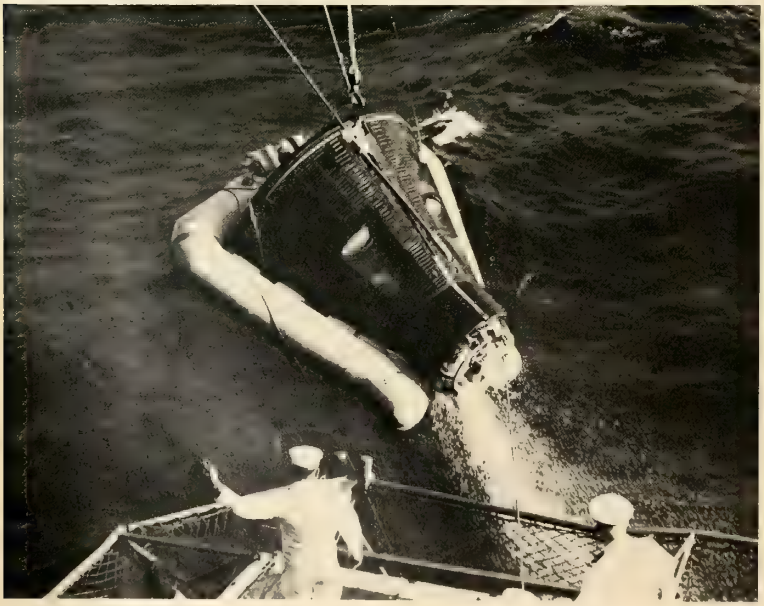
With the *GT-4* astronaut team of James A. McDivitt and Edward H. White inside the spacecraft, it was depressurized. The hatch was opened, then closed, and pressure was built up again.

This simulates the procedure to be followed when a *Gemini* astronaut opens the spacecraft hatch and sticks his head into space. Although this experiment had been tentatively planned for the *GT-5* mission in September, efforts are being made to try it earlier. Apparently, it will be attempted if MSC can qualify the suit in the two months remaining before the scheduled flight.

Details of the test program of the spacesuit and spacecraft were learned following the successful *Gemini 3* flight on March 23. At the post-launch briefing, manned spaceflight officials said the nearly perfect performance of the spacecraft and launch vehicle meant that plans could proceed for the *GT-4* mission, which is now more than a month ahead of schedule.

They reported that the originally scheduled third-quarter 1965 launch date might be moved up to as early as late May or early June (M/R, March 29, p. 13).

GEMINI 3 spacecraft is hoisted aboard USS Intrepid after three-orbit flight.



Erection of the *Titan II* launch vehicle for the mission began at Cape Kennedy last week. The *Gemini 4* spacecraft is scheduled to be delivered this week. If no technical problems develop, the earlier launch date is highly possible.

As preparation began for the upcoming flight, officials said a final flight report on the *Gemini 3* mission would be available in approximately a month.

- **Unanswered questions**—There was still no official explanation for two of the three technical malfunctions that marred the almost perfect flight—the failure of the dc-to-dc converter and the 55-mi. miss of the planned impact point. Some fix on the converter problem is expected in about two weeks, but no estimate was made as to when the reason for the missed impact would be known. Officals said this was because of the many variables involved.

One problem—a constant left yaw drift of the spacecraft—was apparently caused by the water boiler, according to Command Pilot Virgil "Gus" Grissom. The boiler's continuous spilling of water created enough thrust to keep the spacecraft drifting.

The yaw drift was halted about 37 minutes after launch, when the astronaut team stopped using the water boiler and switched to a space radiator for the first time during a space flight.

Grissom stated that it was a most significant first for space flight. "This space radiator enabled us to keep ourselves and the equipment cool by using coolant pumps and conducting the heat away and venting it in space," he added.

- **Breakthroughs**—Among the other Space-Age firsts chalked up during the flight were the first astronaut-controlled re-entry, the first orbit-changing maneuvers and the first successful transmission through the re-entry communications blackout barrier.

Discussing the controlled re-entry, Dr. Robert C. Gilruth, director of the Manned Spacecraft Center, said it

MANNED ORBITAL FLIGHTS U.S. & U.S.S.R.

CMDR.	SHIP	LAUNCH DATE	TIME GMT	WT. (LBS.)	PERIOD	ORBITAL ELEMENTS PERIGEE	APOGEE	INCL.	DURATION RE-ENTRY	HR,MIN
Gagarin	**Vostok I**	12 Apr. 61	06:07	10,418	89.1	108.8	187.7	65.1	12 Apr. 61	1:48
Titov	**Vostok II**	6 Aug. 61	06:00	10,434	88.6	110.3	115.3	64.1	7 Aug. 61	25.18
Glenn	**Friendship 7**	20 Feb. 62	14:47	2,987	88.2	97.6	159.5	32.5	20 Feb. 62	4:55
Carpenter	**Aurora 7**	24 May 62	12:45	2,975	88.3	100.0	166.8	32.5	24 May 62	4:56
Nikolayev	**Vostok III**	11 Aug. 62	08:30	10,428	88.5	112.3	145.8	65.0	15 Aug. 62	94:27
Popovich	**Vostok IV**	12 Aug. 62	08:02	10,428	88.5	111.7	147.1	65.0	15 Aug. 62	70:29
Schirra	**Sigma 7**	3 Oct. 62	12:15	3,030	89.0	100.0	176.0	32.5	3 Oct. 62	9:13
Cooper	**Faith 7**	15 May 63	13:04	3,000	88.7	100.2	165.8	32.5	16 May 63	34:19
Bykovsky	**Vostok V**	14 June 63	12:00	10,441	88.3	109.0	138.0	64.9	19 June 63	119:06
Tereshkova	**Vostok VI**	16 June 63	09:30	10,428	88.4	114.0	145.0	65.0	19 June 63	70:50
Komarov*	**Voskhod I**	12 Oct. 64	07:30	11,731	90.1	112.5	255.6	64.9	13 Oct. 64	24:17
Belyayev**	**Voskhod II**	18 Mar. 65	07:00	11,690	90.9	107.5	307.5	65.0	19 Mar. 65	26:02
Grissom***	**Molly Brown**	23 Mar. 65	14:24	+ 7,000	88.2	100.0	139.0	32.6	23 Mar. 65	4:34

NOTE: Orbital elements refer to initial values and are stated in statute miles. Data on GT–3 is preliminary.

*Komarov's crew included scientist K. P. Feoktistov and physician B. B. Yegorov.

**With P. I. Belyayev was crewmember P. I. Leonov.

***Crewmember with V. I. Grissom on GT–3 was J. W. Young.

offered the possibility that the rigors of space flight might be endured by older men or women. He pointed out that during the *Gemini 3* re-entry, the astronauts received a peak of only 4 g's rather than the 8 g's astronauts pick up in a ballistic re-entry.

"This is a very significant thing," he continued, "and it gives some of us oldtimers like myself maybe a chance that they will be able to stand the rigorous space travel."

In the re-entry communications tests, water was ejected outside the spacecraft into the ionized plasma sheath created by the heat generated by the re-entering spacecraft.

Some 16 lbs. of water was ejected into the sheath and telemetry was successfully transmitted during one-third of the tests. A keyed signal was transmitterd over the voice channel and both were picked up by ground stations. Although the intensity of the signal still was not known, Pilot John Young said he anticipated that the test proved it would be a feasible method for re-entry communications during the blackout phase.

Officials indicated that it would take two or more weeks to pinpoint the reasons for the missed landing point.

- **Short landing**—In discussing the re-entry, Grissom said that approximately four minutes after retro-fire, and at an altitude of 400,000 ft., the onboard computer began indicating that it was taking over guidance of the spacecraft.

"The computer at this time tells us to roll heads down, which is a max-lift position for the spacecraft, and as we keep coming on down, Cape Control at this time computed the bank angle time to use, in case the computer or the guided re-entry didn't work. It sent a bank angle of 45° left and a reverse bank angle time of 11 min./6 sec. after retro fire.

"The scheme we were using, to decide whether the computer was working or not, was that I'd hold to the bank angle that the ground had sent to me rather than flying the angle that the computer was telling me to fly. Then if my computer indicated that a cross range error was being cancelled out, that I was starting to guide, then I would believe the computer and fly the computer the rest of the way in. This is exactly what happened.

"As we came on in, heads down, with only a 45° left bank, the cross ranger zeroed out. My down-range error indicated that we were about 60 mi. short. As cross range errors zeroed out I went to the max-lift position, which is pure heads down, and held that attitude the rest of the way in. My computer indicated from then on that we were 50 to 60 miles short and we were not correcting this out. As it turned out, this was exactly right. When we stopped . . . when the computer stopped guiding at 80,000 ft., it was still indicating that we were on track, but about 50 to 60 miles short."

Officials shortly after the flight conjectured that Grissom may have not picked up from the ground the right bank angle, but this was not true.

Grissom said that a variety of things might have caused the spacecraft to land short of the projected impact area.

"We are still not sure of the delta V we got out of the retro rockets. We've got to confirm what delta V we got out of our last OAMS (Orbital Altitude Maneuvering System) burn over Hawaii. We want to take a look at what the center-of-gravity position is on the spacecraft to see if that has shifted and maybe we weren't getting the lift we expected. We want to check the computations on the ground to make sure that they were accurate. There are a great number of things that have to be done before we know exactly what happened," he said.

- **Official boxscore**—NASA released the following official figures for the *Gemini 3* flight:

Launch time was 9:24 a.m. EST from Cape Kennedy and impact time was 2:17 p.m. EST. The orbital flight lasted 4 hours and 34 minutes. During the first orbit, the spacecraft reached an apogee of 139 statute miles and a perigee of 100 statute miles. After the OAMS system was fired, the second orbit had an apogee of 105 statute miles and a perigee of 99 statute miles. After the final OAMS firing, the third orbit just before retro fire dropped to a perigee of 50 statute miles. ■

About the Cover: Airborne Missile Sight

FRONT-LINE tactical missiles may go aboard Army helicopters and aircraft with a special sight developed by Aeronutronic Div. of Philco Corp., a subsidiary of Ford Motor Co., and the Army Materiel Command.

M/R's cover photo is the first released showing the device being feasibility-tested by Army personnel at Edwards AFB, Calif.

The sight was specifically designed to mate with the *Shillelagh* line-of-sight command-guided missile, currently planned as the main armament of the Gen. Sheridan armored vehicle, which was developed by Aeronutronic and will soon go into production. It is designed to damp out vibrations and moments caused by engines and aircraft flight motions. Such damping would enable a gunner to keep his target within the field of view provided by the sight's optics.

Shillelagh is launched from a closed-breech cannon carried by the Sheridan.

AF Nears Test of Inflatable Station

Viron Div. of GCA Corp. developing five-layer structure that may be launched with Gemini; material samples already tested

THE AIR FORCE plans to begin ground tests of a full-scale inflatable manned space station structure in late July or early August. Now under development by the Viron Division of GCA Corp. of Minneapolis, the structure will harden into a rigid, compartmented cylinder 10 ft. in diameter and 25 ft. long.

Tests and evaluation will begin upon delivery of the full-scale test model to the Air Force Systems Command's Aero Propulsion Laboratory at Wright-Patterson AFB, Ohio. Before delivery of the full-scale model, two models of the chamber built to one-sixth scale will undergo destructive tests.

Plans call for placing them under 7.5 psi pressure in a vacuum for 14 days to test for leaks. One of these scale models will be tested at sea-level pressure at 200°F. The range of temperatures to which the structures are expected to be subjected in space is between — 100° and 200°F. Inflation of the capsulized, folded structure will be conducted at an inside temperature of about 75°F.

- **Five layers**—In fabricating the full-scale model, Viron is building up a five-layer composite material containing a layer of polyurethane-coated nylon on each side of a woven fibrous corrugated material assembled in honeycomb-sandwich fashion, an inner inflation bladder designed to retain internal pressure, and a buffering layer of polyurethane foam. The bladder portion of the five-layer material is included to achieve the ultimate shape of the plastic cylinder.

Using well-known basic "water-cured urethane" techniques, the liquid catalyst mixture, mainly water vapor, will be released from its three-gallon container inside the collapsed cylinder package, expanding it to full size within approximately 2½ hrs. As originally attached to the *Gemini* capsule for its ride into space, the package will measure 10 ft. in diameter by 4 ft. long. It is composed of two rigid outside circular bulkheads with a central bulkhead or divider between them. An explosive bolt releases a tensed spring, throwing off the restraining band around the assembly, permitting expansion to begin.

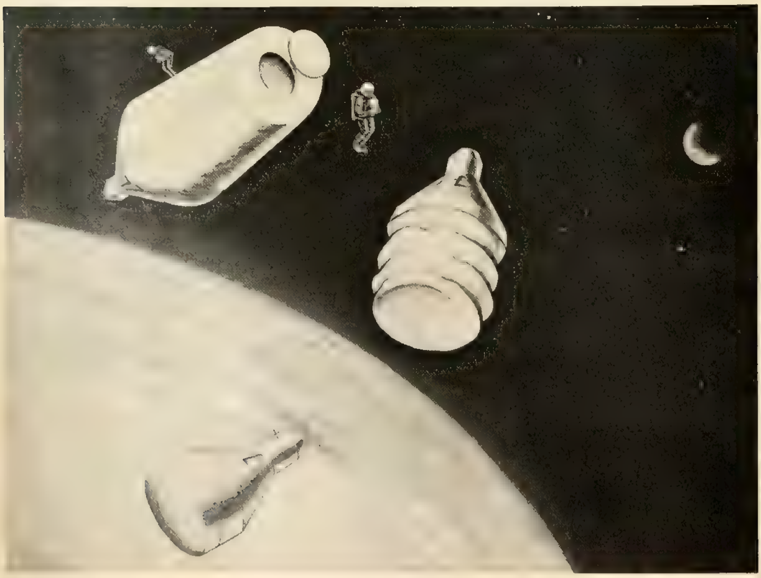
The "forward" compartment, or the one nearest the *Gemini* capsule, will contain the three-gallon catalyst tank, fitted with flexible tubes terminating in a special spray manifold designed to carry water vapor to both sides of the divider bulkhead inside the inflating chamber. All three chamber bulkheads are pre-fitted with rigid elliptical hatches measuring about 36 in. through their longest diameters.

- **Interfacing**—Early diagrams of the deflated chamber package show it fitted directly to the convex *Gemini* capsule heat shield, but the exact method of attachment has not yet been selected. Interface with the capsule may be solved alternatively through fabrication of a special "standoff" plate, attached to the capsule by means of some type of truss structure. Ultimately, the mode of attachment will be governed largely by decisions reached about the type of hatch which will afford exit and re-entry into the *Gemini* capsule.

Water vapor, on release from its storage container, begins inflation of the cylinder at 75°F temperature, at a vapor pressure of 17 mm of mercury. This flow, eventually dispersed into the vacuum of space through controlled ports in the expanding canister, is sufficient to complete inflation, after which the plastic cylinder rapidly becomes a rigid structure.

Although this requirement is not a part of the initial $100,000 contract under which Viron is building one full-size and four one-sixth-scale structures for the Air Force, the inflatable space laboratory's designers hope for a hardened shell able to withstand bombardments of space particles impacting at speeds ranging from 20,000 to 40,000 fps. Samples forwarded to date to Wright Field hypervelocity laboratories have been characterized as "standing up very well." ■

ARTIST'S CONCEPTION of how inflatable cylindrical structure aboard Gemini capsule (bottom) could be expanded by remote control (center), then rigidized by chemical techniques to form space station 10 ft. in diameter and 25 ft. long.



Circle No. 12 on Subscriber Service Card

LAUNCHING

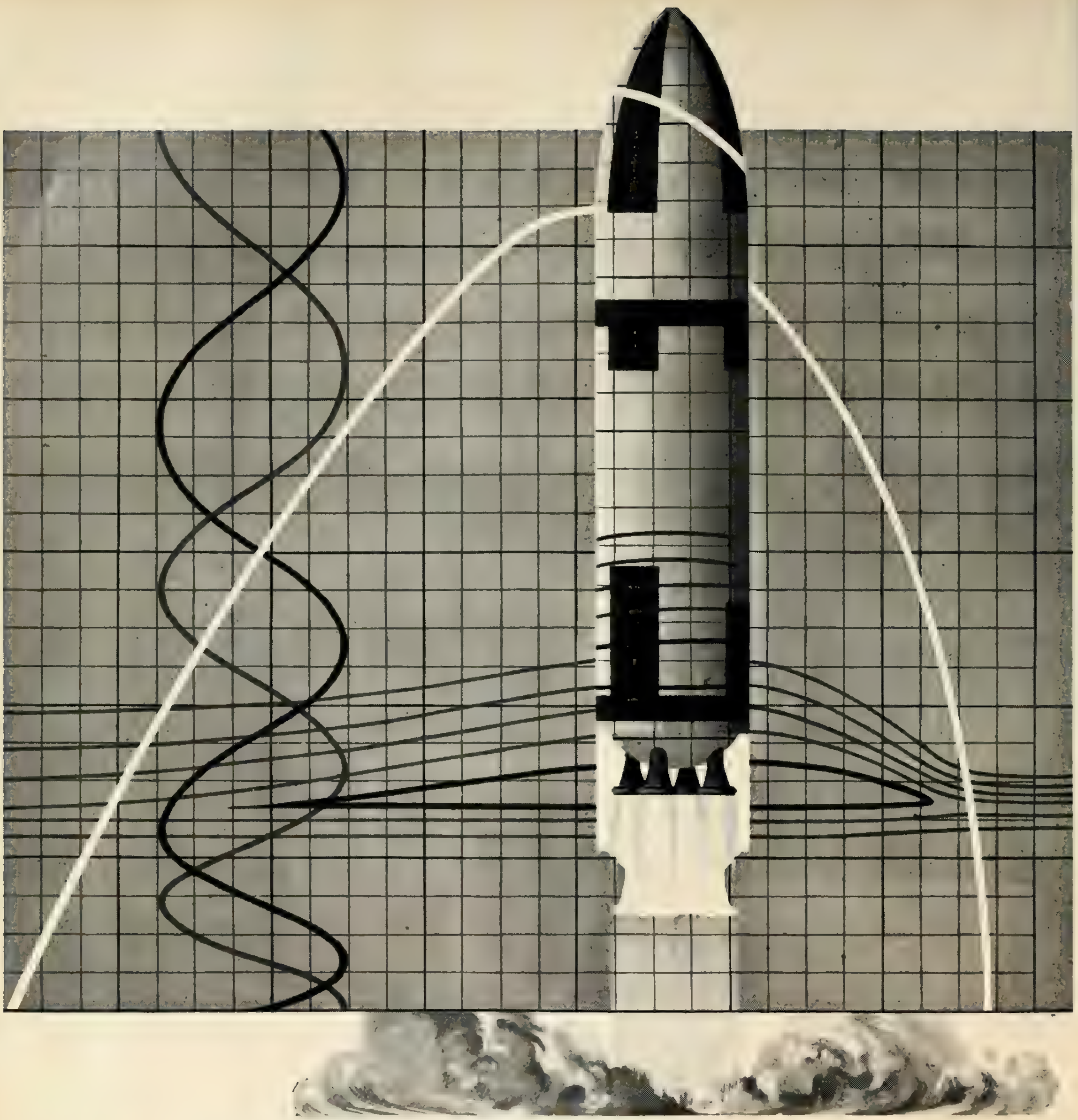
HE FIRST HIGH SILICA FABRICS WITH INTEGRATED QUALITY CONTROL

w the world's foremost weaver and finisher of glass fabrics is producing high silica fabrics for ssile and aerospace industries. For the first time, all processing is under one-plant quality control from glass yarn thru completed ASTROSIL cloth—your assurance of superior performance. ite or call J. P. Stevens & Co., Inc., Industrial Glass Fabrics Department, 1460 Broadway, New York 036/212-OXford 5-1000 • 615 South Clarence Street, Los Angeles, California/213-ANgelus 8-2755.

Fine Fabrics
Made in America
Since 1813

Stevens
Fabrics

STEVENS ASTROSIL™



LOOK AT LOCKHEED . . . IN AEROMECHANICS

Space systems one day will penetrate the atmospheres of Mars and Venus and safely re-enter the earth environment. When that happens, substantial credit will be due scientists and engineers at Lockheed Missiles & Space Company for significant contributions to these missions.

For example: Current work with cryogenic propellants has uncovered new technological problems in materials behavior, structures design, thermodynamics, and fluid mechanics. These require intense investigation. Protection of the payload against various hostile environments involves studies in determining planetary atmospheric characteristics, the search for adequate materials, the development of new analytical techniques.

Exploration of the vast "inner space" of the earth's oceans is an intriguing new frontier. Of particular concern at Lockheed is the development of advanced vehicle concepts and structures capable of withstanding severe, crushing pressure.

The Lockheed team that developed the POLARIS Fleet Ballistic Missile and the AGENA booster/satellite already has provided many answers. Engineers and scientists of all disciplines bearing on the solutions of these advanced problems are invited to submit their qualifications.

For a brochure that gives a complete *Look at Lockheed*, address: Lockheed Missiles & Space Company, Dept. 530, P.O. Box E504, Sunnyvale, California.

LOCKHEED
MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

AN EQUAL OPPORTUNITY EMPLOYER

Technical Countdown

MATERIALS

Sterilizable Batteries, Rockets at GE

Scientists at General Electric's Re-entry Systems Dept. are meeting NASA sterilization standards for space vehicles with thermally-conditioned solid rocket motors and batteries. The solid rocket motor was subjected to three 36-hr. heating cycles at 145°C and then successfully test fired. The 4-in.-dia., 5-in.-long Arcite propellant grain was part of a joint effort with Atlantic Research Corp. In an allied program with the Eagle-Picher Co., a sterilized nominal 8-amp.-per-hr. battery produced 50 watt-hours per lb. to an end voltage of one volt per cell. This performance was achieved before, between and after three separate 36-hr. exposures to 149°C. While at approximately 120°C, the battery put out electrical energy at what amounted to 18-20 watt-hours per lb. The new battery has a specially treated thin organic semi-permeable membrane recently developed by GE and battery plates developed by Eagle-Picher. Both are physically and chemically stable in the hot alkaline electrolyte. Significant characteristics of the membrane include uniform pore size and resistance to high temperatures, alkaline electrolytes and oxidation.

DOD Basic/Applied Research Coupling Initiated

Three major contracts in the materials technologies field let by the Advanced Research Projects Agency of DOD through the military services marks the beginning of a sustained effort to tie basic and applied research to long range defense problems. Several major areas of investigation within the complex materials fields have been chosen by ARPA and the three contracts represent the first group funded. In each case an industrial firm will join forces with a university in attacking the particular problem area through ARPA's concept of "coupling" science to applications. Martin Co.'s Denver Div. will work with the University of Denver on a three-year, $1-million investigation into the high energy rate forming of metals. Union Carbide Corp. with the Case Institute of Technology will probe carbon composite materials for three years under a $2.5-million contract. Monsanto Research Corp. and Washington University of St. Louis, Mo., will conduct a 2-year program of research on high-performance composites with about $2 million in ARPA funds.

Gas Turbine Operates with Gas Lubrication

The rotating machinery in a self-sustaining, closed-system, gas-turbine cycle (Brayton cycle) operated successfully using gas-lubricated bearings in a recent AEC-sponsored test run. The experimental turbine, compressor and associated equipment was designed and constructed by Mechanical Technology, Inc., Latham, N.Y., under contracts with both the AEC and the Dept. of Interior's Bureau of Mines. The test marks the first time a gas turbine lubricated entirely with its own cycle gas has been operated in the U.S. The event paves the way for truly sealed cycles capable of long-term operation, and feasible applications include the production of heat sources for auxiliary space power systems and for compact and mobile power sources for both land and marine use. The demonstration model with its test gas-lubricated compressor is capable of speeds up to 24,000 rpm with turbine inlet temperatures of 1,300°F. The unit can operate on a variety of gases including nitrogen, argon and helium. When operating at design conditions with nitrogen as the cooling and lubricating gas, the unit simulates a turbocompressor for a 30-kw electrical power converter.

PROPULSION

LPC To Build HARP Rockets

Two versions of a gun-launched, high-altitude research rocket for Project Harp will be built by Lockheed Propulsion Co. under a contract with Canada's McGill University. The $50,000 task calls for a total of six rockets for feasibility demonstration purposes. The firings will be conducted at the HARP Barbados Island test site using a surplus 16-in. naval rifle specially modified for the gun launchings. Four of the motors will be Martlet 3-B's containing solid propellant end-burning grains in 40-in.-long heavy-wall motor cases. Two units will be Martlet 3-C's with internal burning grains in lightwall motor cases 75 in. long. The tests will evaluate the ability of the LPC rockets to withstand the 7,000-g launch acceleration. No ignition is planned. The 3-C motors will also use a new, LPC-developed suspension system in the rifle. Project HARP is a joint U.S., Canadian venture aimed at gun-launched rockets for upper atmospheric studies.

ELECTRONICS

Radar Altimeters To Go on More Aircraft

Three more Navy aircraft types will be fitted with radar altimeters developed by the Bendix-Pacific Div. of Bendix Corp. Planes slated for the devices are the Lockheed P3 Orion, an anti-sub patrol plane; the Grumman S2 Tracker, an anti-sub plane carrying both depth charges and torpedoes; and the Grumman C2, a cargo-troop plane operating from aircraft carriers. The radar unit transmits a pulse from the plane toward the earth or water and the time delay to the return pulse is computed and translated into distance in a fraction of a second. The contracts bring to over 3,000 the total number of these units operational in Naval aircraft.

Saturn IB Telemetry Shipped

Data-Control Systems, Inc., of Danbury, Conn., reports it has shipped the third of six data systems used in connection with ground-based telemetry checkout of the *Saturn 1B* to Marshall Space Flight Center ahead of schedule. The firm holds contracts for $1.8 million of the equipment, designated Integrated Automatic Checkout Telemetry Ground Station, which will handle *Saturn S-1B* and Instrument Unit telemetry data.

SPACE MEDICINE

Ground Suit Bio-Instrumentation Contracted

Beckman Instruments has received a contract from NASA for construction of a network of miniaturized physiological and biomedical measuring devices and amplifiers. Fifteen of the units, which will consist of vests with sensing devices and amplifiers to be worn underneath closed-atmosphere pressure suits, will be delivered to the Manned Spacecraft Center. The systems will be used to insure safety of workers in the space simulation chamber for testing flight models of the *Apollo* spacecraft. Each wearer will have his heart and respiration rates, body temperature and blood pressure transmitted along a cable to a control panel outside. Oxygen and carbon dioxide level, suit pressure and temperature also will be monitored.

EOS Advances Ion Engine Art

Sophisticated ionizer design allows size reduction, helps make unit 300% more efficient than previous flight models

by John F. Judge

Pasadena, Calif.—Developments in both powder metallurgy and ion optical techniques at Electro-Optical Systems, Inc. are the keys to a contact ion engine some 300% more efficient than previous flight models.

The unit, which was scheduled for launch aboard an Atomic Energy Commission *Atlas-Agena* Snapshot test vehicle last week, is smaller but much more efficient than previous engines flown in suborbital programs.

The increase in efficiency and reduction in size results from a radical ionizer design—called "sastrugi" because of its resemblance to a windswept snowfield. (The term derives from the Russian word "zastruga," which means groove.)

Previous engines used in flight tests have had button ionizers, developed by the Xerox subsidiary over the past several years. (M/R, April 22, 1963, p.23.)

The EOS engine is a secondary experiment aboard the *Agena* vehicle. The primary test involves operation of the SNAP 10A nuclear reactor generator.

The 970-lb. SNAP 10A is a development of Atomics International Div. of North American Aviation, Inc., under funding from the AEC. Heat produced by nuclear fission in the reactor is converted to 500 watts of electricity directly through thermoelectric elements.

- **Air Force endeavor**—The power thus generated in the orbital flight is to be used for the vehicle's extensive test instrumentation and to test the EOS engine. The engine itself is part of the Air Force's development effort in electric propulsion.

Engine power comes from a battery charged in flight by the SNAP 10A system. The sastrugi engine is capable of about 8 millipounds thrust, but will run at about 2 millipounds during this flight test.

The test program calls for a number of 700-n.-mi. polar orbits after launch from Vandenberg Air Force Base. The ion engine will be fired, stopped and restarted up to 100 times.

Orbit must be assured before the experiments can begin. Then the SNAP 10A start-up sequence will be initiated and the reactor should be in self-controlled operation within 24 hours.

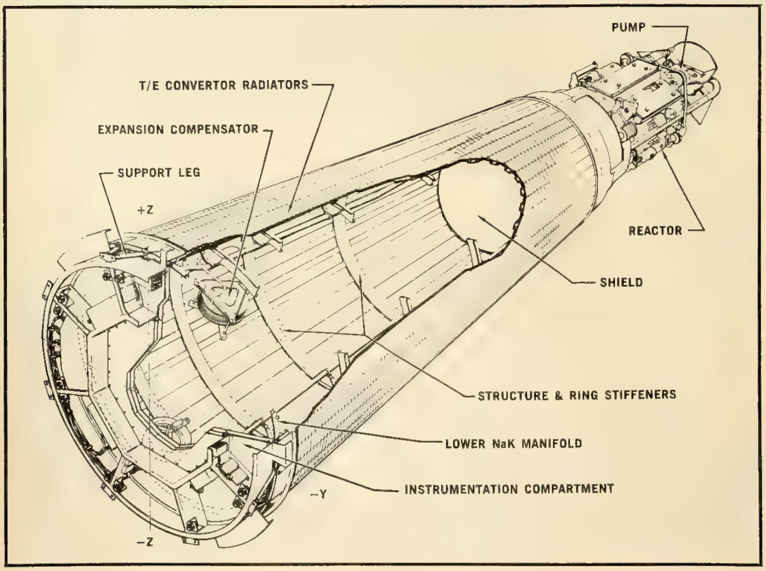
The orbit is crucial. If the planned orbit is reached, the test reactor should not re-enter the Earth's atmosphere for some 3,500 years—long enough for the radioactive materials to have decayed to safe levels after reactor shutdown.

- **Sastrugi design**—The major contribution of the sastrugi configuration is a substantial increase in current density. The face of the ionizer is actually a series of lenses machined onto a block of porous tungsten.

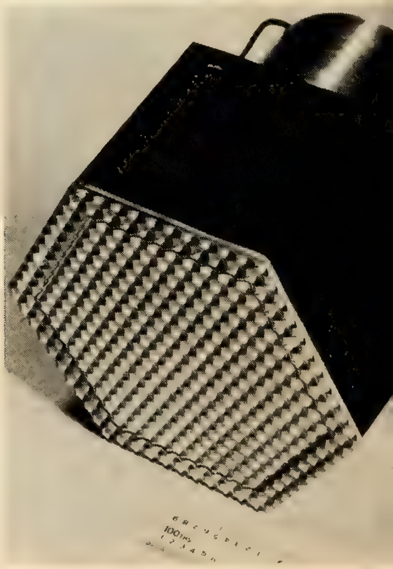
The ion optics improvements are continuing at EOS through a series of experiments involving a digital computer program, electrolytic tanks and an electron gun analog.

The digital computer program generates ion trajectories under full space-charge flow conditions, trajectories of secondary particles such as charge exchange ions or electrons emitted from

LEFT: SNAP-10A nuclear power source is designed to supply electrical power directly through thermoelectric conversion.



RIGHT: Hexagonal ionizer array is representative of ionizer used in secondary experiment aboard Snapshot vehicle. Lenses



Electrical Propulsion—A Summary

There are three major categories in the field of electrical propulsion—electrostatic, electromagnetic and electrothermal. The Snapshop experiment involves the first type, an electrostatic or ion engine.

In ion engine schemes, propulsive thrust is derived from the electrostatic acceleration and ejection of high-velocity ions. The propellant in this instance is cesium, although other elements are used in various programs.

The cesium ions are formed at an ion source and accelerated by an electrostatic field. The high-velocity ions are then neutralized by an electron stream before being ejected from the thrustor.

Although the acceleration produced by the particle stream is very low—in the 10^{-4}g area—the great advantage of the ion engine lies in its low rate of fuel consumption.

This makes possible the continuous application of thrust over long periods in space, where there is little or no resistance to constant acceleration. The specific impulse for ion engines ranges between 5,000 and 15,000 seconds. Thrust levels are in the millipound area.

The flight engine involved in the current test includes a no-moving-part zero-g fuel feed system, an ionizer providing power-to-thrust ratios of 200kw/lb. and a modularized thrustor electrical system allowing a simplified hook-up to the nuclear power supply.

---

the accelerator, and partial space-charge limited-flow trajectories.

The electrolytic tank is used to design electrode shapes to produce uniform space-charge-limit emission. The electron gun analog is used to experimentally measure perveance and interception as a function of a variable such as electrode spacing.

EOS researchers have perfected a technique for simultaneously optimizing ion engine geometry with respect to perveance and electrode clearance by using both the electrolytic tank and the digital computer.

One improvement in the simple sastrugi geometry resulting from such studies lies in contouring the backside of the ionizer surface so that the flow to the front surface more nearly matches the fully space-charge-limited emission.

- **Tungsten processing**—Development of the sastrugi ionizer is based on EOS experience in powder metallurgy. EOS fashions the ionizer from micron-sized spheres of tungsten in such a manner as to leave the spherical shape of each particle intact in the final ionizer plate.

Then the many lenses are carefully machined across one side of the plate. Each lens joins its neighbors in a series of extremely sharp edges. These edges are crucial to the overall efficiency of the ionizer, since the method avoids the inert gaps that existed between the porous tungsten buttons in previous ionizers and thus effectively uses the total surface of the ionizer in processing the cesium fuel.

The multi-focusing ability of the sastrugi design eliminates the beam-forming plate used in previous button engines. Besides the obvious increase in current density, the design allows a reduction in engine size.

The sastrugi design is now being used in endurance tests on EOS contact ion engines. EOS is also developing electron bombardment schemes.

- **Experiment details**—The ion engine is mounted on the payload in this shot to eliminate any influence on the planned orbit. There are no thrust-measuring devices aboard, but thrust can be calculated from other data points.

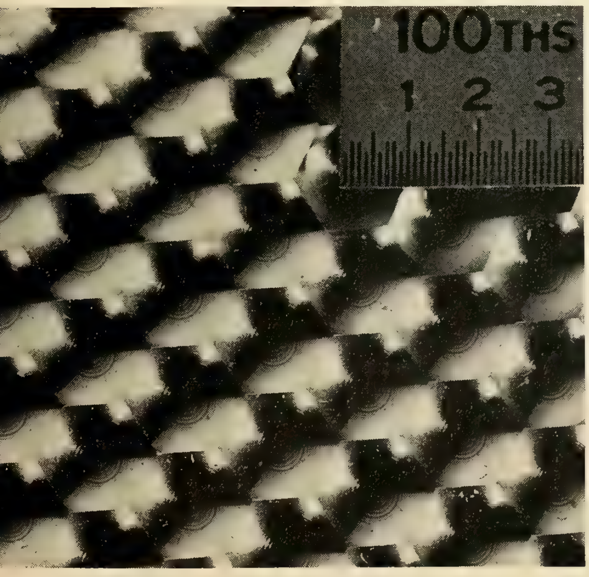
There are 29 data points on the engine in this flight experiment. These will supply information on the operation and performance of the engine during the orbit tests.

The ionizer plate is heated to about 1,100°C by means of a three-phase resistance heater arrangement. The cesium fuel feed system is the EOS zero-g method using the fuel's surface tension energy. (M/R, Sept. 7, p. 23)

Effective thrust with such engines is achieved only after efficient neutralization. In the present flight model, a small bar placed aft of the accelerating plate dumps negatively charged particles into the beam. The beam then becomes a mixture of positive and negative particles and is considered neutralized. ■

are machined into porous tungsten plate. LEFT: Photographically enlarged front view of sastrugi ionizer shows individual lenses.

RIGHT: Jack Davis, EOS propulsion programs office manager, puts finishing touches on ion engine orbital test package.



Re-entry Simulator Will Employ MHD

Air Force working toward 36,000-fps wind tunnel using magnetohydrodynamics both to accelerate gases and to generate the required electrical power

by Donald L. Zylstra

WIND-TUNNEL test facilities that will approximate the temperatures and speeds of space vehicle re-entries into the Earth's atmposphere may soon be achieved by accelerating gas streams using magnetohydrodynamics methods.

Speeds of 36,000 fps are the goal of scientists and engineers at the Arnold Engineering Development Center, Arnold Air Force Station, near Tullahoma, Tenn.

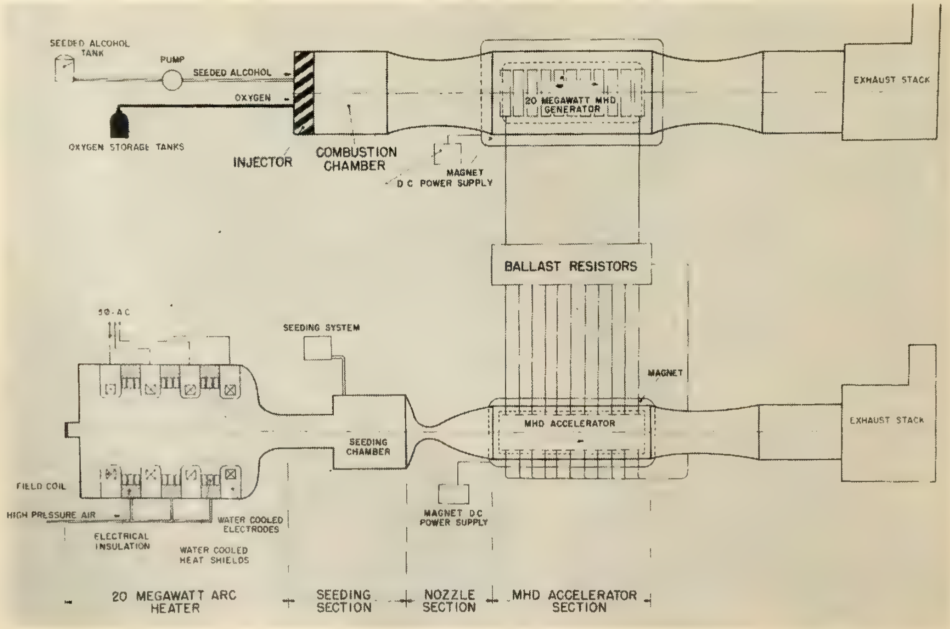
Magnetohydrodynamics already offers a promising method of providing electrical power. Power supplies using this method of generation are believed possible many years ahead of electrical current generated by controlled nuclear fusion. Arnold Engineering Development Center (AEDC) is embarked on a project in what it terms its "Lorho" (for low density) branch that will employ magnetohydrodynamics techniques in *both* directions—for generation of direct-current electrical power and, in turn, using this direct-current source for the acceleration of ionized gases to the speeds simulating effects produced when a space vehicle plunges into its re-entry corridor on return from space.

Experiments under way with acceleration of ionized gases are concentrated almost exclusively on pure gases, mainly nitrogen. But ultimately AEDC is hoping for a design that will accelerate ionized air as it is found in the Earth's atmosphere.

● **Air a preferable medium**—At AEDC, ARO, Inc., the Air Force contract operator, is concentrating on an ionized air stream for eventual use in a Lorho MHD tunnel, prompted by several considerations, including: the need for air to insure the validity of tunnel testing using the same atmosphere space vehicles encounter on re-entry; and present indications that ionized air can be successfully "seeded" with compounds of sodium or potassium, which can be used much more cheaply than cesium, currently a favorite seeding element.

Experiments to date at Tullahoma indicate that seeding materials introduced into gases need not exceed about 1% of the mixture to obtain satisfactory results in promoting ionization. Comparisons of the orders of energy needed to strip electrons from atoms of either sodium or potassium show that this can be accomplished with roughly one-quarter the energy expenditure required for atoms in the gases contained in air—hence the need for seeding techniques in the acceleration of conductive ionized gases.

In the MHD effort to date at Tullahoma, experiments are being conducted with the initial goal of developing an accelerating channel operating at near-


SEEDED ALCOHOL TANK
PUMP
SEEDED ALCOHOL
OXYGEN
OXYGEN STORAGE TANKS
INJECTOR
COMBUSTION CHAMBER
MAGNET
D C POWER SUPPLY
20 MEGAWATT MHD GENERATOR
EXHAUST STACK
BALLAST RESISTORS
30-AC
SEEDING SYSTEM
MAGNET
FIELD COIL
SEEDING CHAMBER
MHD ACCELERATOR
EXHAUST STACK
HIGH PRESSURE AIR
WATER COOLED ELECTRODES
ELECTRICAL INSULATION
WATER COOLED HEAT SHIELDS
MAGNET DC POWER SUPPLY
20 MEGAWATT ARC HEATER
SEEDING SECTION
NOZZLE SECTION
MHD ACCELERATOR SECTION

SCHEMATIC drawing of Lorho MHD pilot wind tunnel planned for Arnold Air Force Station, Tenn.

Common carrier for space

Titan III is available now; who needs it?

Ask the payload builder who has microminiaturized about as far as he can—and still needs more thousands of pounds of thrust. Ask the scientist who has a deep-space experiment to perform—with no cost-effective method of implementing it. Ask the military man who is concerned about mission flexibility. Ask the planners of the functional payloads which already have been scheduled for orbit aboard Titan III.

The U.S. Air Force Titan III combines the best in liquid and solid fuel technology. Precise launch capability. Cost effective. Reliable. Man rated. Flexible. Thrust range, depending upon configuration, from 500,000 pounds to nearly 2.5 million pounds. Handles payloads ranging up to ten tons for a 200-mile earth orbit or two-and-one-half tons for a moon shot. It's available now.

Get the facts on Titan III—a common carrier with uncommon capabilities. Write on company letterhead to Department RC-401, Martin Company, Friendship International Airport 40, Maryland.

MARTIN MARTIN MARIETTA

Circle No. 5 on Subscriber Service Card

atmospheric pressure to produce a velocity ratio of about two in a nitrogen plasma stream, without experiencing undue difficulties with viscous and end effects. The present test facility is emphasizing the solution of problems associated with long-duration operation at conditions suitable for wind tunnel application and toward improvement of accelerator performance.

ARO and AEDC scientists and engineers now believe it will be easier to make corrections to test data for a small amount of seeding contamination in air than it would for the effect of a highly dissociated, nonequilibrium test medium. This approach has the added advantage of lessening severe heat transfer problems and permitting less demanding accelerator design and geometry.

- **Additional facilities planned**—ARO's present test facility is merely the first in a three-step program toward the ultimate Lorho tunnel contemplated at AEDC. The second phase of the effort involves construction of a pilot facility for which funds have already been approved. Ground has already been broken for this $2.4-million project.

If satisfactory results are achieved with the pilot model, the third step would be the construction of a full-scale facility, accommodating a wind-tunnel test section large enough to test future spacecraft models constructed to generous scales. As presently conceived, neither the test facility nor the pilot facility will be coupled with an actual wind tunnel or test sections since their functions would be solely to prove the feasibility of accelerating ionized gases using MHD techniques.

In experiments to date, ARO's test facility has accelerated ionized gas streams at the delivery end of the accelerator section to velocities of 8,500 fps. While the pilot facility contemplates use of seeded exhaust from an alcohol-burning rocket engine to generate the 20 Mw of direct current that will be required to energize the field magnet, the test facility presently in use gets its 2-Mw d-c power supply from 1,700 automobile storage batteries, stacked in banks in a three-story storage building.

- **TVA no solution**—Use of massive rectification equipment to convert Tullahoma's Tennessee Valley Authority a-c power supply to feed the facility has been rejected as a solution that would prove many times more expensive than coupling the rocket motor MHD generator to the pilot accelerator for power supply.

Also, it is expected that ultimately AEDC's Lorho accelerator and its wind tunnel will require direct-current power in the hundreds of megawatts—probably as high as 300 Mw. To make TVA's a-c power of this magnitude available with rectification, the load would have to be drawn from the TVA system gradually, possibly increasing the buildup over a period of nearly half an hour, with a similar period required for shutting down. With the rocket engine generator, direct current generated from its seeded exhaust gases should be available independently of any external power source, as soon as the rocket generator reaches peak operation.

- **System performances**—In a comparison of the performance of the three systems—test, pilot, and ultimate Lorho accelerator/tunnel facility—Tullahoma technical people offer the following figures, some already achieved, some tentative:

- **Present facility**—In the test plasma-jet facility, nitrogen, heated by an electric arc, passes into a combination seeding and stilling chamber, where pressure is 3 to 3.5 atmospheres; temperature is 4,500-5,000°K; and velocity is Mach 0.1 to 0.2. Although it is probably the largest of such facilities now in operation, the ARO plasma-jet accelerator is only 0.687 sq. in. cross-section area at the throat of the nozzle delivering the gas into the accelerator section. There the magnetic field is applied perpendicularly to the direction of the movement of the plasma, and an electrical field is applied in a plane perpendicular to the magnetic field and a direction perpendicular to the movement of the plasma.

On delivery to the accelerator chamber, the plasma stream pressure equals 0.44 atmospheres; temperature, 2,750°K; velocity, 6,000-6,500 fps. After acceleration in the chamber, exit figures read pressure 0.2 atmospheres; temperature, 2,750-3,000°K; and velocity, 8,500-12,000 fps. ARO engineers indicate that their goal of 100% acceleration of the gas over the speed at which it leaves the seeding chamber is only about 30% achieved in experiments to date, but that 12,000 fps is regarded as an achievable goal with this equipment.

If the test accelerator were coupled with a wind tunnel, the diameter of the test section it would be capable of driving is estimated to be about 18 in.

- **Pilot facility**—Based on tests to date, ARO scientists and engineers have established the following goals for the pilot facility with its 20-Mw rocket motor-generated d-c power supply: pressure of ionized gas in the seeding chamber, 10 atmospheres; temperature, 5,200°K; and velocity, Mach 0.3. Entering the accelerator the numbers would be: pressure, 0.3-0.5 atmospheres; temperature, 3,100-3,300°K; and velocity, 8,000 to 10,000 fps. Figures for the accelerated plasma exiting the accelerator would be: pressure, 0.04 to 0.08 atmospheres; temperature, 2,900-3,100°K; and velocity, 20,000-25,000 fps.

Coupled with a wind tunnel, this pilot facility, with its nozzle throat cross-section measuring 2.4 sq. in., could feed a wind tunnel test section 3-4 ft. in diameter.

- **Eventual aim**—Goals set by ARO scientists and engineers for the ultimate Lorho accelerator/wind tunnel facility include: plasma in the seeding chamber at pressures from 30 to 100 atmospheres; temperature, 4,500-5,000°K; and velocity, Mach 0.2. Entering the accelerator, the figures would be: pressure 0.3-1.5 atmospheres; temperature, 3,000-3,400°K; and velocity, 8,000 to 10,000 fps. Numbers for the accelerated gas stream leaving the accelerator would be: pressure, 0.04 to 0.25 atmospheres; temperatures, 2,800-3,100°K; and velocity 20,000 to 36,000 fps.

This ultimate Lorho facility would have a nozzle throat measuring 8 to 10 sq. in. at its smallest cross section and would drive a tunnel test section up to 20 ft. in diameter. In addition to the estimated 300 Mw d-c power supply required for this facility, another 100-Mw supply of alternating current would be needed for the arc heater.

- **'Freeze out' the boundary layer?**—In applications of the gas acceleration obtained in an MHD wind tunnel, theoretically only the gas or air near the center of the stream would move at maximum velocity, with boundary layer air near the walls of the expansion nozzle at the intake end of the wind tunnel decreasing in velocity. This boundary layer air poses an increasing headache for wind tunnel engineers, reducing drastically the portion of any tunnel cross-section that can be used for valid testing of models.

Experiments now under way contemplate pumping liquid hydrogen at a temperature of −423°F through a jacket surrounding the nozzle at the accelerator exit. This technique is expected to "freeze out" a large proportion of the boundary layer, even though the gas stream moving through the nozzle center would have a temperature of several thousand degrees.

Depending upon the type of test being conducted and other operating conditions, Lorho facility scientists hope for eventual test periods in an MHD tunnel ranging from "two or three minutes to an hour." Such a time availability is described as a large step toward the day when wind-tunnel testing over the entire spectrum of space vehicle flight can be simulated—from launch to re-entry and landing.

Col. D. D. Carlson, an Air Force aeronautical engineer, is the project manager of the Lorho program and Will Wimbrow is the director for ARO, Inc. ■

BOEING 727
727
BOEING

Designing Great Airplanes Takes GREAT ENGINEERS

BOEING NEEDS:

Engineers in the following assignments to carry on in the nearly half century Boeing tradition of designing tomorrow's airplanes today for military and commercial use. These requirements are in Boeing Airplane Divisions with locations at Wichita, Kansas and Renton, Washington.

FLIGHT CONTROL SYSTEMS — Establish design criteria and specifications for flight control systems, subsystems and components; selection of components; and monitoring of flight test.

CONTROL DYNAMICS — Servo control analysis to develop automatic terrain-following concepts, load-alleviating stability augmentation systems and automatic flight control systems. Experience in analog computer programming and familiarity with digital computer techniques.

AERODYNAMICS — Perform analyses of aerodynamic characteristics effected by airplane control systems and stability augmentation systems. Experience in systems analysis and working knowledge of analog computers.

STRUCTURAL DYNAMICS — Analysis of complex structure virbration, airframe loads and response, and application of probability theory to structural design criteria.

LOADS ANALYSIS — Perform aeroelastic loads analysis, coordinate loads testing and establish requirements for extensive design loads investigations.

STRESS ANALYSIS — Perform research of load-paths and strength characteristics of aircraft structure. Perform strength checks and formal stress analyses. Establish programs and document analysis data.

HYDRAULIC SYSTEMS — Analysis, testing and design of hydraulic systems. Experience with system pumping, control components, and heat transfer of high pressure systems (knowledge of current techniques used in hydraulic servo valves for powered flight controls).

ENVIRONMENTAL CONTROL — Heat transfer analysis with application to air cycle conditioning of jet aircraft. Emphasis upon avionic equipment conditioning to develop new environmental conditioning concepts.

ANTENNA SYSTEMS — Design, performance, evaluation, and analysis of radome, antenna, and RF transmission systems. Experience in antenna, radome, or wave propagation.

NAVIGATION AND GUIDANCE SYSTEMS — Analysis of electromechanical systems and derivation of system transfer functions to quantitatively predict system performance. Experience in feedback control systems.

OTHER POSITIONS AVAILABLE IN: • FLIGHT TEST OPERATIONS • FLIGHT TEST INSTRUMENTATION • FLIGHT TEST DATA PROCESSING • ELECTRONIC COUNTERMEASURES • HUMAN FACTORS • TECHNICAL PUBLICATIONS • WEIGHTS • FATIGUE ANALYSIS • RADAR TECHNOLOGY • WEAPONS DELIVERY SYSTEMS • ELECTRICAL SYSTEMS • OPERATIONS RESEARCH

All positions require a B. S. or advanced degree in engineering, physics or mathematics. You are invited to send your resumè or letter indicating your specific area of interest to either:

Mr. Tom Sheppard, Dept. BCB
Boeing Airplane Division
P. O. Box 707
Renton, Washington 98055

Mr. Gerald Caywood, Dept. BCB
Boeing Airplane Division
4300 E. MacArthur Road
Wichita, Kansas 67210

BOEING
AIRPLANE DIVISIONS
RENTON, WASHINGTON ■ WICHITA, KANSAS

An Equal Opportunity Employer

Ranger Program Exceeds Expectations

Program photo-evaluation team finds Moon is smooth enough for manned landings; Part I of a two-part M/R report

by Willard E. Wilks

THE FORTHCOMING REPORT of NASA's Project *Ranger* photo-evaluation team will rate the program as successful beyond expectation in its objective of photographing the small-scale topography of the Moon.

In addition to a definite finding that the Moon is smooth enough for manned landings, the investigators report that the three successful *Rangers* revealed "a multitude of good, solid facts" about the lunar surface. These include:

—Existence of a grid pattern, encompassing small-scale fractures and other features, that apparently covers the entire lunar globe. This general alignment of innumerable linear surface features, including some crater chains, in both maria and highlands runs in three main directions and remains consistent down to the smallest dimensions of a few feet discernible in the *Ranger* photographs.

A grid system encompassing the Moon's larger features was recognized long ago in Earth-based observations, but the fact that small detail also follows this pattern was called a general phenomenon "entirely new and unpredicted."

It is believed the grid pattern is caused by cracking. Evidence of cracking in such fine detail raises a question as to what effect such an extensive system of cracks might have on surface landing. If the surface is composed of loose particles, as most investigators seem to believe, this, coupled with the evidence of subsidence noted in craters and rills, could pose a hazard to manned landing attempts on maria.

One of the photo-team investigators reported after a recent visit to volcanic ash fields in Hawaii that it is possible to walk safely on such areas, because the ash compresses readily in the cracks. Whether a hazard will be posed on the Moon can only be answered by on-the-spot investigation.

—Positive relief—bumps—on the surface are very sparse, and small bumps are extremely rare. This is a very important piece of information for *Apollo*, with regard to design of the Lunar Excursion Module (LEM) landing gear.

—Size-frequency distribution of craters is now known in the areas photographed, and extrapolations can be made. Information was specifically sought concerning craters smaller than one third of a mile across; an abundance of such data are now in hand. This hard information may be reasonably fitted into comprehensive theories about the surface.

—What all of the photographs have shown is that small relief features of the surface are predominantly craters; craters constitute the topography in all scales, down to the smallest details seen.

—Several kinds of craters, in terms of shape, can now be recognized and classified into different types of features. It is believed a whole new group has been identified.

—Slope-frequency distributions of the lunar surface are now known. A big program to extract this sort of data in detail from *Rangers VIII* and *IX* photographs lies ahead for researchers.

—A significant amount of information on photometric characteristics of the surface has been gleaned from the pictures. Details of rays and rills have been revealed—in both cases it has been determined that craters form some of them—and important new details in terms of ridges and other structures have been seen on the maria.

—A "treebark" structure associated with shallow depressions has been seen in enough of the photographs to give investigators considerable confidence that this is a characteristic feature. Investigators say it follows the general alignments of the grid pattern and may be caused by cracks.

It is generally conceded that the photos have confirmed earlier theories that craters are the result of impact, vulcanism and other internal causes. Another area of general agreement is that the lunar surface material consists of rather small particles, including fine dust. Some investigators lean toward the view that the surface material is only a foot or two thick.

At the same time, one member of the photo-evaluation team reports that the hypothesis that the Moon may be covered with very thick dust layers is neither confirmed nor rejected by the *Ranger* data. He points out that Earth-based observation does not support the hypothesis anyway .

- **Wall smoothness**—One of the surprises of the *Ranger IX* photos was the apparent smoothness of the walls and the central ridge and peak of the crater Alphonsus. This led to early speculation among some investigators that some lunar highlands may offer better landing spots than the maria.

However, following the preliminary look at the pictures, members of the photo-evaluation team pointed out that not all highlands appear to be this smooth. Most look rougher than the maria.

Some of the apparent smoothness of Alphonsus' walls may be caused by the brighter lighting on these features in the pictures, and, perhaps, because their color is lighter. Nevertheless, members of the team feel the evidence is good that the walls are indeed much smoother. They note extensive flat areas on top of the walls (shown in the right side of the 16th-from-last full B frame), where there should have been no illusory effect in the photograph.

- **Still room for arguments**—Based upon the list of purely factual findings obtained from the photographs—such as the grid pattern seen in small detail and size-frequency distribution of craters—individual investigators have drawn a number of conclusions, some preliminary, about the lunar surface. While the mass of data has enabled a convergence of views among scientific observers with regard to some interpretations, the photos also have revealed new problems on which disagreements may be expected.

One assumption on which there seems to be reasonable agreement is that the grid system is due to subsurface cracks, which may be revealed on the surface as either depressed or raised areas—the latter caused by molten material coming up through cracks or by piling of material around venting fissures. Thus the grid system encompasses countless fine and large fractures and depressions, some rows of craterlets, and rills (though not all rills fit the pattern), as well as ridges on the maria and very low humps and bumps.

The pattern of the grid, with lunar north at the top, is northeast-southwest, northwest-southeast, and north-south.

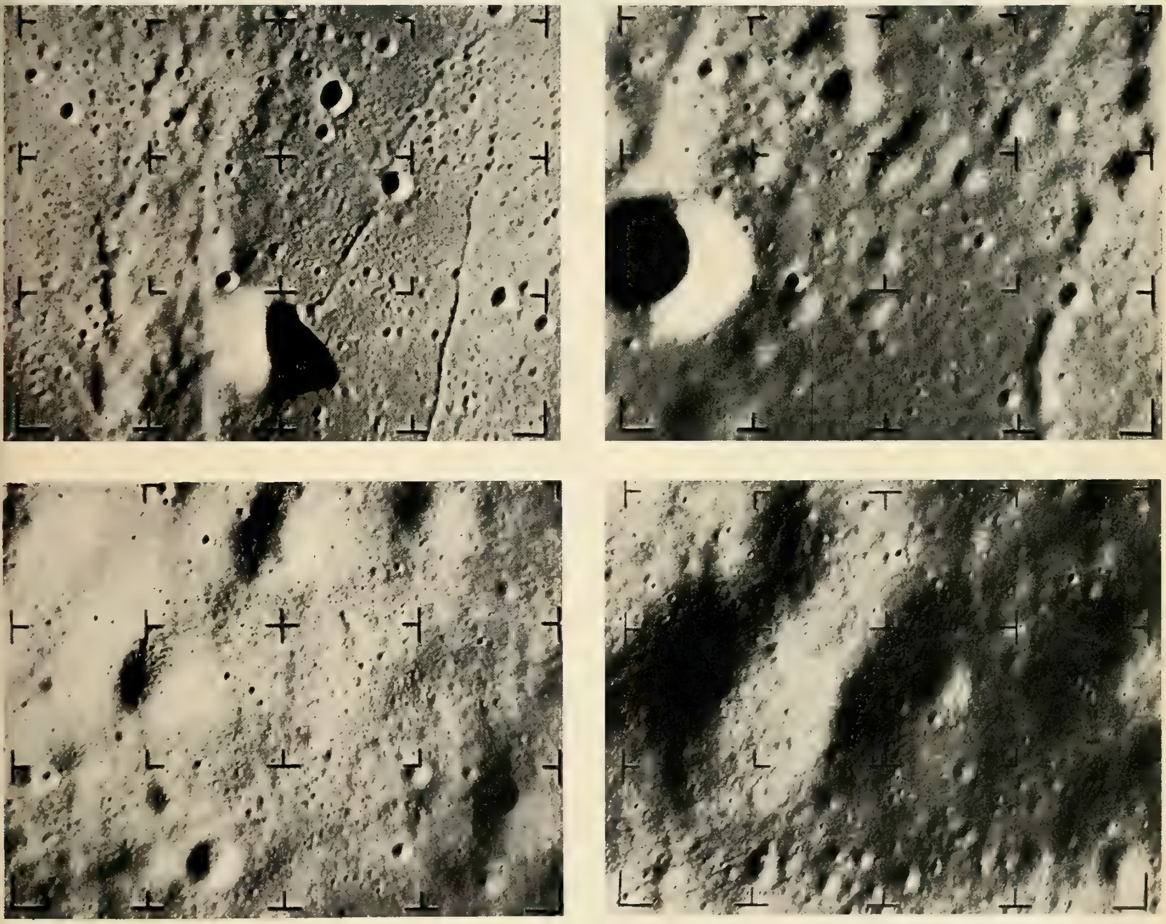
A similar grid pattern has been spotted in aerial photos of some areas of the Earth, including Canada. The pattern runs in the same prime directions as that on the Moon, with regard to the axis of rotation.

While the explanation for such cracking remains to be found, a theory is that it dates back to early lunar times and is probably connected with tidal history: the Moon was once much closer to the Earth, and as it solidified and receded from the planet, its shape changed from ellipsoidal to nearly spherical, causing a global fracture system. The cracking occurred when molten lavas still underlaid the lunar surface, so that they would well up to form ridges.

Visibility of the grid pattern in such fine detail is considered by some investigators to be further evidence that the layer of lunar surface material is only a foot or two deep.

- **Pocking**—Two spokesmen for Eastman Kodak Co. told the Society of Motion Picture and Television Engineers in Los Angeles last week that a slope steeper than 23 degrees and larger than 3 ft. in diameter occurs at least once every 200 sq. ft. in the area of final *Ranger VII* photography. The experts—G. T. Keene and T. F. Kerwick—said changes in tone reproduction and resolution may have helped produce a misleading impression of smoothness in closeup views.

As a result of tracking data from earlier *Ranger* missions, JPL was able to better calculate the impact time of *Ranger IX*. Because the radius of the Moon was found to be nearly two miles shorter than had been supposed, officials revised their estimate. ■



RANGER IX PHOTOS show with unprecedented clearness lunar global pattern of alignment of cracks, rills, crater strings and humps, ridges and bumps. TOP LEFT: Eighth-from-last Camera A frame taken 38.8 secs. before impact at 58-mi. altitude (dimensions 28 x 26 mi.), shows region of central peak of Alphonsus, with rill running through its shadow toward upper right. TOP RIGHT: Penultimate Camera A picture, taken 8.9 secs. before impact at 12.2-mi. altitude, shows area of 5.8 x 5.3 mi. Rill shown in preceding photo appears on larger scale. Large crater toward left margin is 1.6 mi. across. Second rill near right margin is resolved as series of chain craters. BOTTOM LEFT: Last Camera A shot, 2.97 secs. before impact and at 4.5-mi. altitude, shows area of 2.1 x 2.0 mi. Several large shallow depressions with "treebark" texture in their walls are evident, as well as many dimple craters near top and left lower margins. Craters as small as 40 ft. are visible. BOTTOM RIGHT: Last full Camera B frame was taken 5.5 secs. before impact, at altitude of 8.3 mi. Dimensions are 1.6 x 1.4 mi. Picture shows several major shallow depressions with numerous dimple craters and fine structure in shadowed area. Smallest craters shown are about 30 ft. across.

IC Lines Increase, Prices Decrease

Steady sales rise should be further spurred by greater industrial use; a review of newly introduced circuits

by Michael Getler

NEW YORK—The International Convention of the Institute of Electrical and Electronics Engineers (IEEE) has once more served to usher in the next phase in the development, production and use of integrated circuitry (IC).

At the recent meeting here (M/R, March 29, p. 30), important reductions in circuit and IC module prices were announced or promised for the near future.

In meetings held in the preceding several years, the spotlight was on the technology itself and the battle for its acceptance. With respect to U.S. military and space customers, who provided the initial impetus and continue to provide the major market, this battle has been won. Prices must be reduced, however, and production and yield figures improved, before IC manufacturers can hope to make a large dent in the commercial-industrial electronics field.

If development continues as expected, actual non-military equipments making fuller use of the technology should go on display at next year's meeting here—and, indeed, will probably be shown at the WESCON (Western Electronics Show and Convention) August meeting in San Francisco.

Apart from military systems displays and a few commercial equipments, this year's meeting did not reflect widespread use of IC's. On display, however, was a large amount of digital test equipment, much of which was an outgrowth of the penetration of IC's into computer and control system utilization.

• **Cost cut ramifications**—IC cost reductions should have an impact on observers beyond those fully convinced of IC advantages and who have been waiting for prices to drop. The technology may be expected to affect the equipment design and marketing plans of many manufacturers who have paid little attention to the field.

The dropping of prices on many lines by the major circuit manufacturers should also make it more difficult for systems firms to clearly decide on whether or not to make or buy these circuits for use in their own systems.

A big reason for the price cuts in many cases, however, is a relaxation in packaging and environmental specifications of the circuits, many of which are plainly earmarked for industrial use. Much of the advantage also grows out of increasing use of plastic-type encapsulation methods and some overseas production.

Manufacturers of IC equipments for the military and space programs, where the use of IC's is expanding even more rapidly than was visualized in some of the most optimistic projections, will find that most circuit prices will continue to reflect premiums paid for very high reliability and environmental protection, with significant, but less spectacular, price reductions growing out of refined production techniques.

Mixed Impressions At IEEE Meeting

Observers at the recent 1965 IEEE show and convention in New York City carried away two chief impressions—one positive and one negative. On the plus side, the credentials of those in attendance were excellent. This was reflected in the exhibition areas.

On the minus side, technical sessions for the most part continued to be dry, poorly attended and heavily padded with material that was mediocre and/or had already been presented elsewhere. Attendance was less than 60,000; 65,000 had been predicted.

Some industry officials see total sales of IC devices possibly hitting $75 million in 1965. Sales for 1964 have been estimated at between $40-50 million.

• **The roster**—Among the new IC developments introduced at IEEE this year are:

Fairchild Semiconductor—A new epoxy package brought forth by Fairchild Semiconductor, replacing the standard TO-5 metal can, which houses a binary flip/flop and will lead off a string of future IC devices packaged in this fashion by the firm. Fairchild claims this technique will allow the firm to market silicon circuits at less than half the price of any previous industrial-rated IC. The first flip/flop is now available at $2.70 each in quantities of 100 or more.

Fairchild General Manager Dr. Robert N. Noyce said that epoxy packaged gates and buffers will be available within three months and that these two circuits will be priced at less than $1 each in quantity. The epoxy packaged circuits, according to the firm, are functionally identical to the metal-can industrial series.

Fairchild's ability to knock down its prices further is, in large measure, expected to grow out of its decision to use its Hong Kong manufacturing facility to turn out IC's as well as transistors.

Signetics Corp.—Signetics, which added 28 new semiconductor IC's to its already extensive line, also announced price cuts of up to 40% on its premium MIL-range line of DTL circuits. F. J. Van Poppelen, Jr., vice president of the firm, a subsidiary of Corning Glass Works, said the new prices provide nearly a 50% reduction in cost per gate function, which now are as low as $3.75 per function in quantities as small as 100.

Texas Instruments, Inc.—TI introduced 100 new products at IEEE, and also claimed significant cost-per-circuit-function reductions with new multi-function J-K flip/flops in its Series 53 line of medium-speed digital IC's. Each silicon bar contains 85 component elements, the firm reports. While gates with up to four to six functions per bar have been produced, TI claims an industry first in integrating two complex flip/flop circuits in one bar.

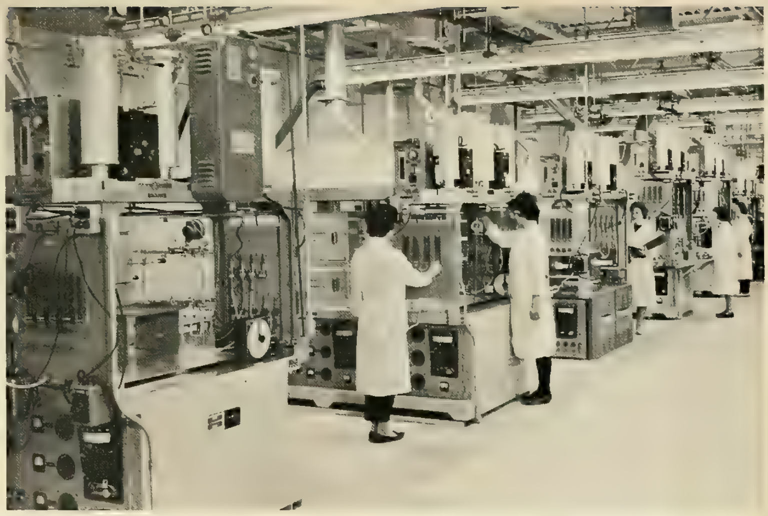
TI also claimed new economies for its Series 73 industrial temperature-limited multi-function IC's, and introduced a new Series 55 high-frequency IC sense amplifier for magnetic core memory amplication and a video differential amplifier of the same series.

Philco Corp.—The firm announced that it will triple microelectronics production by July 1, showed eight new high-speed low-power RTL devices in its MW/3 line aimed at aerospace use, a new J-K flip/flop in its milliwatt micrologic group, three additions to its microenergy logic line, and one new analog circuit, a 60-mc RF-video amplifier.

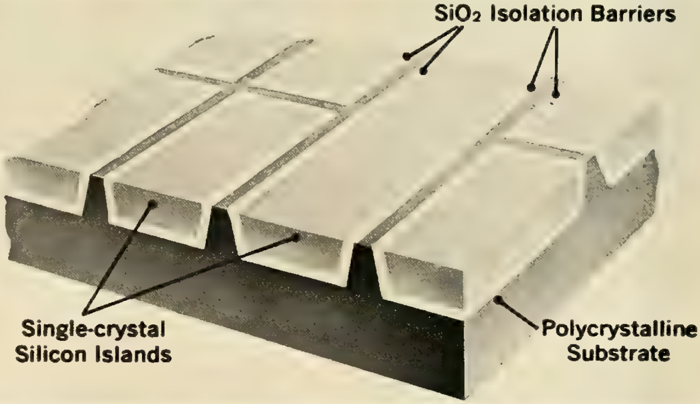
General Electric—GE used IEEE to introduce two new microelectronic circuits. A monolithic IC, actually a version of one developed and being supplied for the *Minuteman* ICBM, is being marketed as a high-speed device with good resistance values. It is primarily applicable to industrial-military shunt switching uses. The second device is a hybrid thin-film amplifier designed mostly for aerospace work, especially in systems requiring impedance transfer such as in IR sensors or photomultiplier outputs, according to the firm.

Computer Control Co., Inc.—A major industry supplier of discrete digital logic modules, Computer Control also jumped into the IC arena at IEEE for the first time, announcing its "μ-PAC" line. These circuits, operating from DC to 5-mc, use the NAND function for positive logic and can also be used to directly implement the NOR function for negative logic, or AND-OR logic, according to the firm. The modules are monolithic IC assemblies supplemented by some discrete hybrid combinations mounted on glass-impregnated epoxy cards.

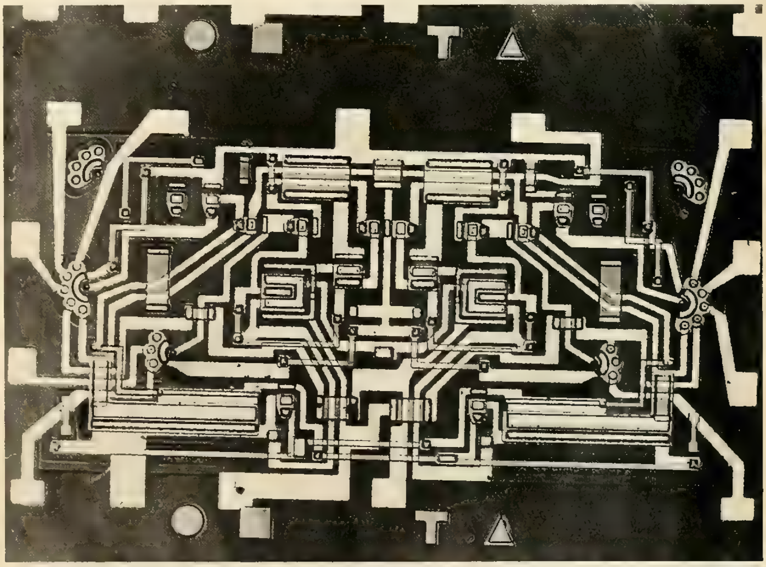
General Instrument Corp.—GIC used the occasion to announce formation of a new microelectronics division to produce IC's designed around the



ABOVE: Diffusion furnaces in the microelectronics operation of Philco Corp.'s Lansdale, Pa., division, in which monolithic microcircuits are being processed.

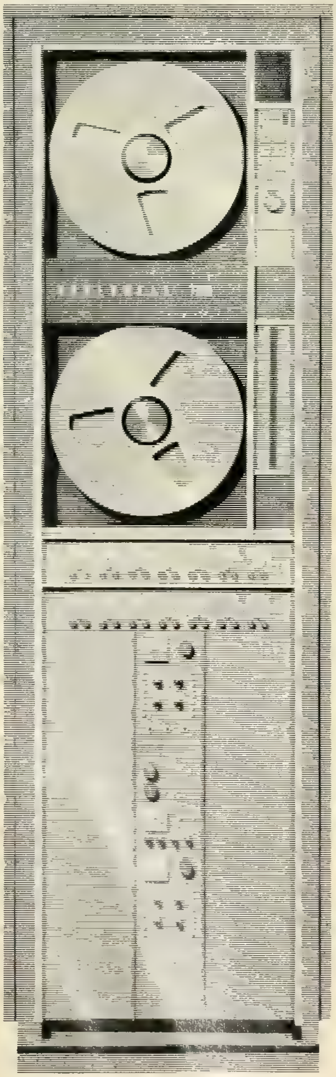


ABOVE: Radiation, Inc., DTL device, which incorporates "waffle-wafer" isolation technique. Method is said to offer considerable flexibility in IC wafer geometry. BELOW: One of a series of 20-mc Sylvania flip flops that ANDs up to three inputs at J and K terminals and triggers on clock pulses as narrow as 20 nanoseconds.



The Honeywell 7700 introduces these four significant advances in analog magnetic tape instrumentation:

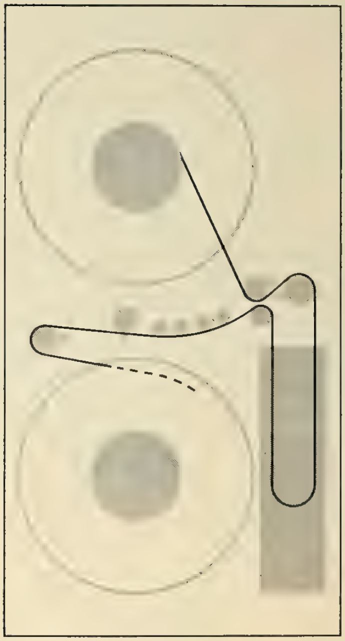
TIME DISPLACEMENT ERROR—Timing errors between record and playback can originate in dimensional changes in the tape caused by temperature, humidity and tension variations as well as differences in tape speed between record and playback. These effects have been minimized through use of a tape-controlled servo on the playback mode. Until now, however, high inertia systems could only reduce instantaneous timing errors to about 1 millisecond. The new Honeywell 7700 low inertia, high-response servo reduces this error to 1 *microsecond* at 120 inches per second.



FLUTTER—In the past, flutter has been reduced by use of high inertia drive systems which lose their effectiveness at low frequencies and low speeds. The high-response servo in the Honeywell 7700 virtually eliminates flutter below 100 cps and holds wideband flutter below 0.25% from DC to 10KC at 60 ips.

DYNAMIC SKEW—If data on two or more channels are to be compared, it is essential that varying time differences between channels caused by dynamic skewing of the tape be reduced. The use of vacuum column isolation and a 13-inch edge guide ahead of the record-playback heads reduces dynamic skew in the Honeywell 7700 to approximately one-third of that in state-of-the art analog systems.

SIGNAL/NOISE RATIO—Noise caused by electronics, tape and the tape transport can mask small amplitude data changes. Efforts to improve linearity, drift and other parameters are fruitless if a high percentage of noise is present. The Honeywell 7700 will produce signal-to-noise ratios as great as 48 to 52 db rms. This is a 2-to-1 improvement over the 40 to 44 db noise found in other FM systems.



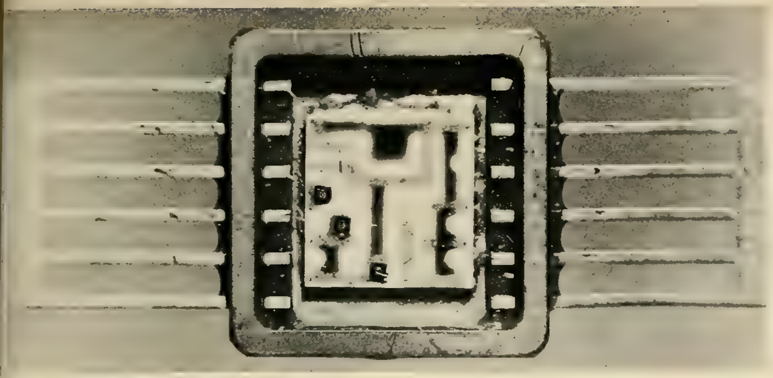
The Honeywell 7700 is an 80 KC FM-640 KC Direct system built specifically to preserve the quality of your most critical data.

For complete specifications, call a scientific field representative at your nearest Honeywell office, or write Mail Station 402, Honeywell, Denver Div., Denver, Colo. 80217. In Canada: Toronto 17, Ontario.

DATA ACQUISITION SYSTEMS

Honeywell

Circle No. 6 on Subscriber Service Card



THIN-FILM General Electric amplifier features high input impedance and no loss in voltage from input to output; has military aerospace product application.

metal-oxide semiconductor, and also field-effect transistors. Both of these devices are considered to have bright futures. GI also announced the development of the first two devices, a complex 21-bit MOS microelectronic shift register, and an MOS-FET, which reportedly offers protection against voltage overloading. The new division will also encompass the company's on-going efforts in hybrid circuits.

Radiation, Inc.—The company had added a new line of integrated DTL devices, including a new NAND/NOR gate, flip/flops, line drivers, and gate expanders. The new gate, they report, has a propogation delay time of 10 nanosec., power dissipation of 10 milliwatts per gate, and noise immunity of 1,000 millivolts at 25°C.

The new line uses what Radiation engineers call their "waffle-wafer" isolation technique, which reportedly provides considerable flexibility in IC wafer geometry. The firm uses the same technique in a new, unique monolithic diode matrix. A standard flat pack, according to the firm, will accommodate up to a 100-diode matrix using any configuration with 14 leads.

Sylvania—The Semiconductor Div. introduced its new SF-50, 20-mc J-K flip/flop series. Alvin B. Phillips, general manager of IC operations, said the series offers AND's up to three inputs at J and K terminals and triggers on clock pulses as narrow as 20 nanosec. The firm also announced development of a 20-mc synchronous binary counter made from four of the new circuits.

- **Other major developments**—Among the other major manufacturers exhibiting at IEEE, Westinghouse engineers report adding some 28 new IC's to the firm's line, including a new and complex NAND gate. Just before IEEE, Westinghouse also announced significant reductions in its DTL circuitry, much of which is used in military hardware. Motorola Semiconductor Products, Inc., also announced several additions to its standard line. Raytheon Co. engineers cited major reduction in per unit production costs for microelectronic analog circuit modules.

Among the new hybrid circuits displayed was a device developed by Burroughs Corp. that is the first in a series of units to use the firm's recently developed single-sided, "glassivated" semiconductors, which the firm says also has allowed major cost reductions. The new circuit also uses thick-film resistors, and is to perform a storage or latching function in memory driver modules. ■

---

space electronics

Laser Coherence Problems Reduced

Sylvania/Stanford team announces techniques that channel all energy of high-power, multi-mode unit to a single frequency

by Charles D. LaFond

New York—Two new techniques for use with gas lasers result in an output wherein all the energy of a high-power, multi-mode laser is at a single frequency.

Developed by engineers at Sylvania Electric Products, Inc.'s Mountain View, Calif., facility and by Stanford University consultants to the firm, the techniques effectively solve the problem resulting from not true coherence associated with existing lasers—particularly in communications, spectroscopy and radar applications.

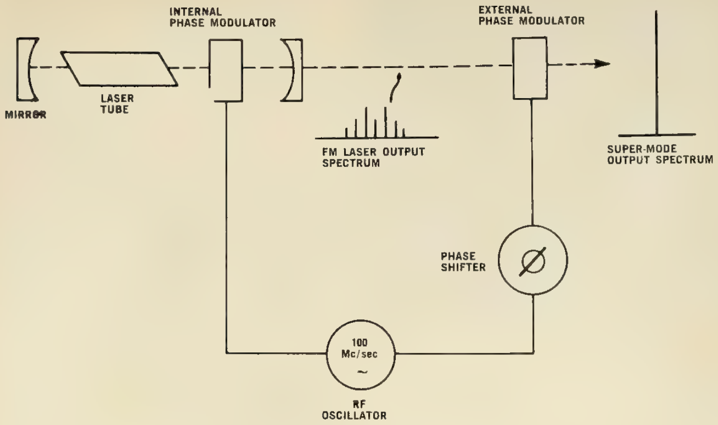
First disclosure of the laser advance was made by the firm at the recent Institute of Electrical and Electronics Engineers Show and Convention here and in a paper by S. E. Harris and O. P. McDuff, Stanford University, entitled "FM Laser Oscillation—Theory and Experiment."

Sylvania's Mountain View R&D group will press efforts to apply the new systems to surveillance in the light and infrared regions of the spectrum, according to Dr. Burton J. McMurry, manager of the facility's Optics Dept. Other research groups within Sylvania will press radar applications.

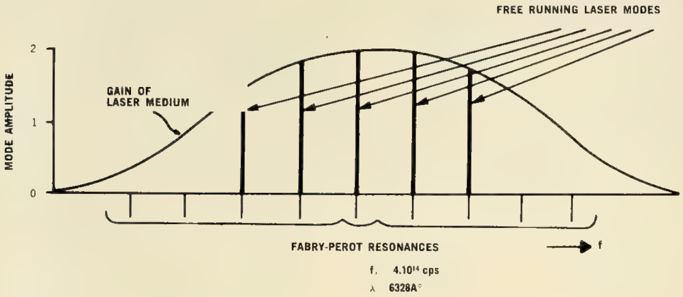
- **"Incoherence" problem**—Present lasers, said one Sylvania official, might be likened to the spark-gap transmitter of early radio days. Output signals were rough or noisy, with many frequencies emitted simultaneously. Existing lasers, using a Fabry-Perot cavity, similarly radiate many frequencies rather than a discrete frequency. They are coherent only when compared with the total incoherence of a typical light source.

Dimensions in a Fabry-Perot cavity are considerably larger than the wavelength of any signal within the optical range. Thus, the cavity is resonant in many high-order modes (as shown in the accompanying top curve). The laser "oscillates in all Fabry-Perot modes for which the laser medium has gain greater than the cavity losses," said Dr. McMurry.

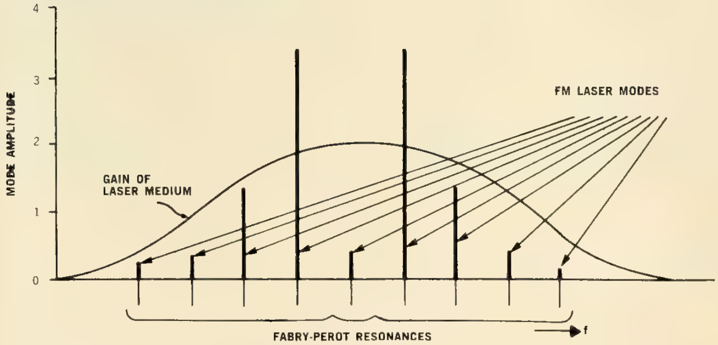
It oscillates in a number of modes equally spaced in frequency, and the spacing is directly related to the length



Super-mode laser showing FM laser plus external phase modulator.



Free-running laser modes.



FM laser modes with modulation index of two.

of the Fabry-Perot cavity. Thus, for a cavity with mirrors of one-meter spacing, mode separation is 150 mc. Each mode, said Sylvania engineers, oscillates with amplitude and phase relatively unaffected by other modes. The output beam, therefore, contains many randomly phased oscillations at different but closely spaced frequencies.

For some time, attempts have been made to produce a single-frequency output. These have fallen generally into three approaches: a reduction of cavity length such that only a single Fabry-Perot resonance falls within the laser-medium gain curve; either insertion of loss in the cavity or reduction of laser gain such that only a single Fabry-Perot mode has a gain exceeding the cavity losses; use of complex Fabry-Perot configurations having more widely spaced resonances.

Each approach has produced the desired end, but with either a loss in power output or reduced frequency stability.

- **FM approach**—The FM laser concept was the brainchild of Dr. Stephen E. Harris, a Stanford University professor and consultant to Sylvania. Conceived in October, 1963, the approach was developed by Harris and Russell Targ of Sylvania's Optics Dept. A working system was shown last year.

Their prototype employs a conventional helium-neon gas laser containing a phase modulator within the Fabry-Perot cavity. The prototype has shown that when the phase modulator is operated at a frequency nearly equal to the spacing between adjacent Fabry-Perot modes, the free-running modes assumed amplitudes and phases comparable to the sidebands of an FM optical signal, but with all the power of the original free-running laser beam (see the accompanying bottom curve).

The modulation is achieved by introducing an R-F field to a KDP crystal inside the laser cavity. The electrically induced axis of the crystal is oriented parallel to the laser polarization. The field applied to the crystal alters its index of refraction, producing a time-varying change in the optical path length of the Fabry-Perot cavity. The result is comparable to vibrating one laser mirror at the modulation frequency and thus phase-modulating the laser modes.

In essence, new modes are produced by the sidebands. Upon attaining sufficient amplitude, they stimulate emission in the gain curve such that the original modes drop below threshold and cease oscillation. The new modes, said McMurry, are driven oscillations and have "the phases and amplitudes appropriate to the FM sidebands which they comprise."

The optical signal in the FM laser is swept in frequency throughout the gain-curve width of the laser medium. The output, McMurry disclosed, is free of the noise associated with random phase fluctuations of the various modes in conventional lasers. Further, he pointed out, the FM laser does not produce noise from a photodetector at the mode-spacing frequency.

- **Super-mode approach**—The second laser technique was conceived by Gail A. Massey, also of Sylvania's Optics Dept. in Mountain View. By passing the output from the FM laser through a second phase modulator, driven 180 degrees out of phase but with the same modulation index as the first phase modulator, a monochromatic optical signal can be produced.

This "super-mode" beam is not frequency modulated and it provides a discrete frequency with almost no energy loss. Further, according to Sylvania, the super-mode signal is free of many of the sources of noise produced by the conventional laser.

Because of their excellent spectral characteristics, both laser approaches are expected to find applications as optical data carriers, local oscillators in optical heterodyne receivers, radars and also as research tools. ■

Oceanography Promising Market For Microcircuit Manufacturers

NEW YORK—Microelectronics used in combination with new, expendable oceanographic instruments linked to ships by a hard-wire telemetry data system could open up a substantial new market for U.S. manufacturers of microcircuitry.

An ocean scientist says widespread employment of this concept would create a demand for "hundreds of thousands" of instruments.

As evidence of the need for such equipment, James M. Snodgrass, a division head at the Scripps Institution of Oceanography, La Jolla, Calif., cited current problems with conventional depth/temperature-sensing bathythermographs (BT's).

Addressing the recent meeting here of the Institute of Electrical and Electronic Engineers (IEEE), Snodgrass noted that these devices, which often become "involuntarily expendible," are designed as underway instruments. He cited, however, these drawbacks: ships often have to slow down considerably to use them; despite the fact that they are designed to operate down to 900 ft., they do not perform well below 450 ft.; and, even though they are recoverable, they frequently act "as a lethal missile" during recovery.

Snodgrass said expendable BT's would have major military, commercial and scientific value. They would make it possible to gather data without slowing the speed of the vessel from which they were deployed—an advantage of special importance for ASW ships.

• **Reasons why**—Microelectronics would be necessary for several reasons—primarily for logistics, since large numbers of devices would be carried aboard. Snodgrass feels that the oft-mentioned economic virtue of microcircuits produced in large quantity would apply to this mission. In addition, he foresees dividends in the form of more rugged sensors with reduced sensitivity to pressure changes, lower power requirements, and higher data-point resolution.

Snodgrass believes that use of micromodules in a building-block fashion will eventually expand the sensing capabilities of single instruments into multiple measurements—adding conductivity, light, and oxygen sensors, for example, to more traditional temperature and pressure data-gathering. He also feels that microcircuitry ought to ease BT calibration problems.

• **More possibilities**—Other specific opportunities in oceanography for electronic systems designers were pointed out at the session on undersea technology.

For example, P. M. Fye of the Woods Hole Oceanographic Institute, Woods Hole, Mass., said there would be a definite need for microelectronic control systems in deep-submergence vehicles, operating under pressures of perhaps 30 atmospheres at 20,000-ft. depths, for regulating the flow of oxygen within the very narrow limits required for life support at those depths.

Such systems also appear to be necessary for "man-in-the-sea" programs, now under study within the Navy and at private institutions, which envision "free swimming" capabilities for man to depths of 600 ft.—possibly 1,000 ft.—within the next five years.

J. P. Craven, chief scientist at Navy's Special Projects Office and instrumental in the Project Seabed ocean engineering study last summer, said he believed helium-oxygen mixtures may allow extension of free swimmer capabilities to the 600-ft. level. These were recently demonstrated at 200-ft. depths in Navy's Sea Lab experiment. Extension to 1,000-ft. depths could lie in the development of hydrogen-oxygen mixtures which can be procured in abundance from the ocean environment, according to Craven.

While pointing to the simplicity inherent in this approach, he also warned of the requirements for precision gas-mixing and of additional study of the human reaction to hydrogen under pressure.

Craven also sees possibilities for radioisotope heating systems used in proximity to free swimmers, with water providing a natural shielding. He says the isotope of polonium "seems attractive" in generators for heating thermal suits.

In addition, he foresees a major role eventually developing for fuel cells as on-board power for deep submersibles, although he expects more conventional lead-acid batteries and newer silver-zinc batteries to predominate in the near future. Craven claims it should be possible to achieve power-to-weight ratios of 6:1 and power-to-volume ratios of 4:1 in favor of fuel cells. Beyond this, nuclear power appears to offer ultimate simplicities, but major advances are needed in the energy-conversion schemes with which the reactors would interface. Craven says reactor-thermionic or MHD systems coupled to low-voltage free-flooded acyclic motors may represent an ultimate system, but that this is strictly speculation.

Craven stressed that the Navy was hoping that systems of ultimate simplicity eventually would emerge from the complexities in design of deep submersibles. He envisions some future vehicle control systems possibly evolving through use of hover jets and fluid amplifiers (M/R, Feb. 8, p. 18). Although jets are inefficient at higher speeds, Craven feels that there will be some form of circulation producer around the basic vehicle that can be precisely triggered by fluid amplifiers.

• **Long-term data needed**—Assistant Secretary of the Navy Robert W. Morse also asked industry attendees to pursue additional studies of the behavior of solid-state devices under long-term pressure conditions—a field little understood at present.

Morse said that these devices, even when enclosed in a pressure hull, were still subjected to pressures of 5 atmospheres. He also called for more long-term data on heat dissipation and humidity problems for electronics operating under these conditions. ■

NAA System Would Avoid Booster Bending

by Rex Pay

ANAHEIM, CALIF.—A digital technique for preventing bending in *Saturn V*-class boosters from coupling into the autopilot system and breaking the booster apart is being developed by Autonetics Division of North American.

The system may also provide a means to prevent bending in the first place, and may have important application in the Advanced Manned Strategic Aircraft.

Bending in missiles has always been present but has been getting progressively more difficult to handle as booster size has increased. The reason is that the frequency of bending has been dropping from about 10 cps in the earlier missiles down to about 1 to 1.5 cps in boosters of the *Saturn V* class. This comes uncomfortably close to the 0.5 cps frequency of the vehicle's short-period rigid-body control system.

The danger is that the short-period system will sense the bending frequencies as rigid-body attitude changes and respond by steering the vehicle in a way that increases the bending.

The Spectral Identification Adaptive Control System (SIACS) being studied by Autonetics takes out the bending frequencies from the control system before they get to the actuator.

It is the subject of a 10-month study being carried out under a $65,000 contract from NASA's Marshall Space Flight Center, Huntsville, Ala.

Under an add-on contract, Autonetics will investigate the possibility of extending the technique from passive removal of bending frequencies to active adjustment of the short-period control to prevent bending of the vehicle.

- **Wider application foreseen**—The importance of this technique goes beyond its application to large boosters. Bending in low flying aircraft is already a serious problem, as can be seen by the B-52 tail-strengthening program.

The problem will be even more serious in the Advanced Manned Strategic Aircraft (AMSA), which will fly lower and at higher speeds. Bending caused by buffeting will decrease the life of the terrain-following aircraft significantly by subjecting it to heavy fatigue loads. The buffeting could also render the pilot incapable of useful work.

- **Possible range problems**—The Air Force is concerned with the effect on range that movement of control surfaces to take out bending modes may have. However, it is possible that this penalty can be avoided. AMSA is reported to have a variable-geometry wing of the F-111 type. With bending suppression, the wings could probably be extended further at high speeds, giving a useful improvement in performance, as well as a smooth ride.

A number of additional advantages are promised for the launch-vehicle use of the Spectral Identification System. In the past, the sensor package of launch-vehicle autopilots has been located at a bending node to minimize interference with the short-period control system. This has often meant putting the package in the center of a fuel tank, well away from the main autopilot package and difficult to service.

An alternative method of detecting bending mode frequencies is by locating sensors at each end of the vehicle. In this gyro-bending technique, the rigid-body motion is subtracted from the two sensors and the system gain is adjusted to balance their outputs for the first bending mode.

- **Location solved**—The system being studied by Autonetics allows the sensor package to be located with the rest of the autopilot equipment in a readily accessible instrument bay. By means of digital filtering, bending mode frequencies are identified in the sensor output and taken out of the control system.

Specific requirements in this study are to be able to control three bending modes in a vehicle of the *Saturn V* class under the most severe loading.

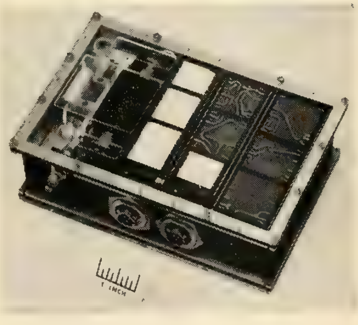
The technique used is to set up a spectral filter for each mode. Five integral filters make up each spectral filter, for a total of 15 filters in the system. A signal is tapped off the short-

EIMAC

Aerospace Telemetry Transmitters Excel in S Band Operation

This 2-watt transmitter uses a triode-cavity power oscillator to achieve higher overall efficiency than is possible with all-solid-state transmitters. Frequency stability is achieved by an AFC servo loop referenced to a crystal oscillator. Tuning range is 2.2-2.3 Gc. Total volume is 48 cubic inches. Modulation linearity (maximum deviation from best straight line) is ±0.5% from ±10 Kc to ±300 Kc, and ±2.5% from ±10 Kc to ±1.5 Mc. Amplitude modulation is less than 1%. Susceptibility requirements of MIL-I-26600 are met. The solid state power supply operates from 28±4 Vdc with over 80% efficiency.

For information on the EM4527 transmitter, contact Eitel-McCullough, Inc., San Carlos, Calif. In Europe contact Eitel-McCullough, S. A., 15 rue du Jeu-de-l'Arc, Geneva, Switz.



NOW ALSO AVAILABLE FROM EIMAC
MODEL EM4534 3.0 WATTS 1.435 TO 1.535 Gc
MODEL EM4567 8.0 WATTS 2.2 TO 2.3 Gc
MODEL EM4575 4.0 WATTS 2.2 TO 2.3 Gc

See us at our hospitality suite—Shamrock Hilton Hotel—NTC Show, Houston, April 13-15

Circle No. 10 on Subscriber Service Card

period sensor package and fed to the spectral filters, which measure the frequency at which maximum power is concentrated in each of three bending-mode frequency bands. The maximum-power frequency is assumed to be the bending frequency.

Three notch filters in the forward loop of the autopilot are automatically adjusted to the three maximum-power frequencies to take out bending frequencies, preventing any control action being developed in response to them. In this way, the spectral filter decouples the bending modes from the short-period control system.

- **System is sensitive**—The studies indicate that the spectral filter can process and identify bending mode frequencies in one period of the lowest frequency of interest. This means that if a 1 cps bending mode appears, about one second will be required to do something about it.

The technique is not limited by knowledge of the bending modes. The exact frequency of these modes is not needed, only an indication of the frequency band in which they can be found. The system thus promises greater flexibility than previous ones.

The spectral filter cannot, however, identify bending frequencies when these are equal to those of the short-period control loop. If, as seems likely, boosters develop to sizes that produce this equality, an active system of bending control will be needed.

J. M. Johnson Jr., chief of advanced control systems, Autonetics data systems engineering division, says the technique used to find the frequency at which the bending energy is concentrated is to select five frequencies in the band in which the frequency is likely to occur and multiply the signal from the sensor in the short-period control system by orthogonal kernel functions of these frequencies.

As five frequencies are investigated, each mode-frequency identification channel involves 10 multiplications. Each modified signal from an integral filter is then squared and added to its orthogonal equivalent. The resulting signal is proportional to the spectral power at the frequency of the kernel function.

A curve-fitting technique is then used to discover the location of the peak spectral power from the sample of five points in the spectrum.

- **Data processing detailed**—As the system is digital, a time-sampling technique is used for the multiplication and other data-processing functions. Once the mode frequency is identified, it is filtered to take out variations caused by random interference. The intention is to rely heavily on past information so as not to follow random movement.

The signal that identifies a bending mode is used to adjust the compensator in the forward loop of the short-period control system. It is converted into a Z transfer function for this purpose. In fact, a seventeenth over eighteenth order transform is obtained, giving a very-high-order servo. One advantage of the digital technique is that the denominator of the Z transform can be adjusted independently of the numerator, giving considerable flexibility in comparison with analog mechanization.

In practice, there is a trade-off between speed of response of the correction system and the accuracy with which the bending modes are identified. Some accuracy can be traded in the interests of gaining speed. The system constantly re-adjusts itself so that any error in the first adjustment is constantly reduced. The optimum response will be reached after two or three cycles.

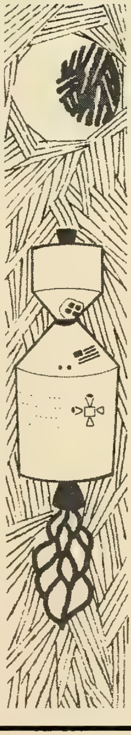
- **Identification crucial**—Johnson explained that current efforts were directed toward optimizing the identification technique. In particular, the best form of kernel function was being sought. Square waves now look most promising.

Aim of the Autonetics study is to specify an operational system for use on large launch vehicles. Johnson emphasized that the study was concentrating on a physically realiable system compatible with state-of-the-art hardware. The real-time integral filters can either be realized as a special-purpose computer or they can be part of the main flight computer.

The sensor package for the autopilot can be located with the main autopilot unit in an instrumentation compartment. The pitch and yaw rate sensors would probably provide the signal to be filtered for bending mode information. These sensors probably could be time shared through one spectral filter, at the speeds being considered.

For active control to reduce bending, the notch filter compensator unit would be removed and the sensor arrangement would have to be changed so that bending could be differentiated from the short-period rigid body movements.

The signal from these sensors would be passed through spectral filters to identify the frequencies of the bending modes and then routed through decision logic to the flight-control elements. For the control of large bosters of the *Saturn V* class, use of reaction-control jets at the nose of the vehicle in conjunction with the main flight controls at the nozzle would probably have advantages for control of bending, because of favorable boundary layer effects. ■



MISSION ANALYSTS
What will You be doing in 1969?

If you act now, you could be working with TRW Space Technology Laboratories in its new Manned Spaceflight Department at Houston and be a vital part of the Apollo Program. As you know, the Apollo lunar probe is scheduled for 1969.

TRW Space Technology Laboratories is now staffing its new Houston facility. STL has responsibility to NASA for Apollo mission planning, mission analysis and real-time program development. Consequently, STL has ground-floor opportunities in Houston that may never be available again. STL needs employees with experience and training in these areas:

Mission Analysis
Strong analytical ability and technical originality with broad background in flight mechanics, astronautics, missile guidance and mission performance.

Trajectory Analysis
Familiarity with the use of digital computation, analytically inclined, with background in space mechanics.

Astrodynamics
Theoretical background in celestial mechanics, orbit determination and/or related fields of math, physics or astronomy.

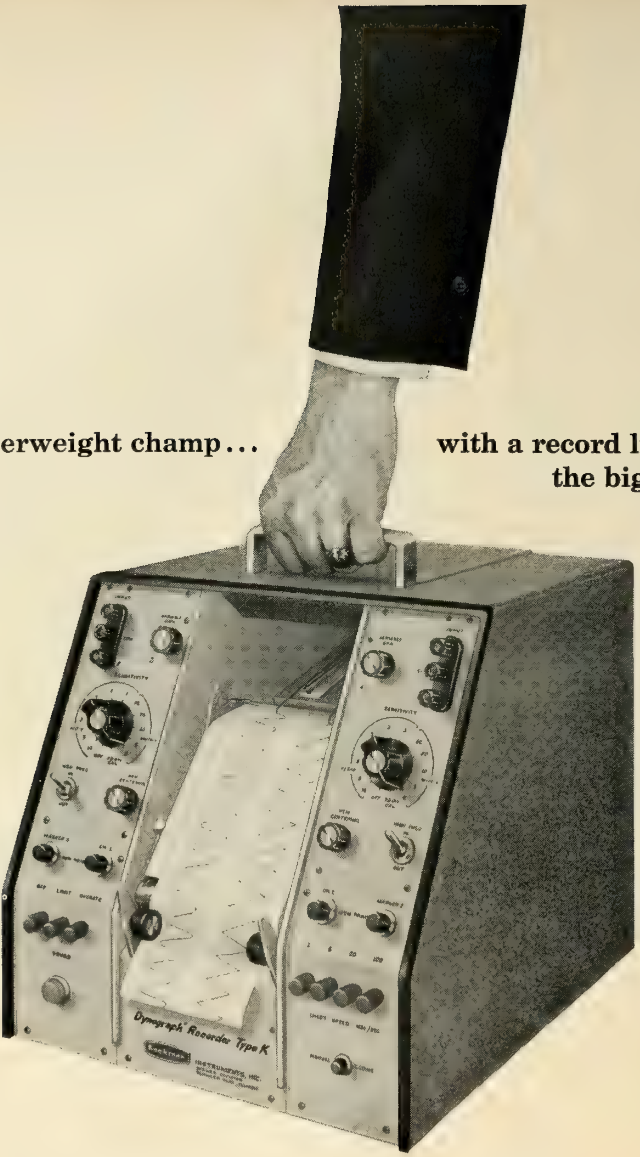
Guidance Analysis
Familiarity with techniques for missile guidance and experience in orbital mechanics, random processes and statistics.

ACT NOW! Forward your resume immediately to S. A. Shirley at STL's address below.

TRW SPACE TECHNOLOGY LABORATORIES
THOMPSON RAMO WOOLDRIDGE INC.

One Space Park – MR-11
Redondo Beach, California
An equal opportunity employer

A new featherweight champ... with a record like the big boys



Meet the Offner Dynograph® Recorders' baby brother – a new 2-Channel Portable Recorder. It incorporates every good feature you want in a portable oscillographic recorder, and it's priced under $1,300.

The Type K Dynograph provides unusual sensitivity in a very small package. Total weight is less than 40 pounds. You can select either ink or heat rectilinear, or ink curvilinear recording. What's more, the specs are excellent: sensitivity range – 2mv/div to 10v/div; common mode rejection – 1000:1 or better; linearity – 0.5%; measurement range – 0.002 to 400 volts.

If you need heavyweight performance in a lightweight recording package, contact your local Offner Division Sales Engineering Representative. He can tell you all about the new Type K Dynograph 2-Channel Portable Recorder. Or, write direct for Data File 721.

Beckman® INSTRUMENTS, INC.
OFFNER DIVISION
SCHILLER PARK, ILLINOIS • 60176

INTERNATIONAL SUBSIDIARIES: GENEVA, SWITZERLAND; MUNICH, GERMANY; GLENROTHES, SCOTLAND; PARIS, FRANCE; TOKYO, JAPAN; CAPETOWN, SOUTH AFRICA

Circle No. 7 on Subscriber Service Card

The Industry Week

New Activities

Goodyear's Aviation Products Div., in what it terms "a logical extension of several of our existing activities," has announced a new program to explore and develop products having marine and oceanographic applications. A Marine Products Dept. will be established within the division. Goodyear notes that the new activity ". . . will permit us to participate in this new field with many of our present customers, notably the aviation and aerospace companies, which have already initiated programs in these areas." . . . *Advanced Technology, a space engineering division of H. J. Sherwood, Inc., of Cleveland, has announced plans to begin operation in the near future in Edgewater, Fla. The firm will be involved in future program studies, design and design consultation projects and writing and publication of technical literature.*

New Facilities

Motorola's Semiconductor Products Div. has begun construction of a 13,500-sq.-ft. expansion to its Phoenix, Ariz., facilities. Included in the new construction will be a 9,000-sq.-ft. plating facility and a 4,500-sq.-ft. chemical processing building. The $400,000 plating facility is designed specifically for plating semiconductor components. The new construction is scheduled for completion in August. . . . *Texas Instruments, Inc., Dallas, has announced plans to begin construction this spring of a 100,000-sq.-ft. addition to its metallurgical and control products manufacturing facility in Attleboro, Mass. Texas Instrument's Metals & Controls, Inc., subsidiary has also announced plans for construction of a new facility in Central Lake, Mich. First section of the new 10,000-sq.-ft. plant is due to begin operation by July.* . . . The Foxboro Co. of Foxboro, Mass., has announced plans for a new $2-million, 120,000-sq.-ft. building to house the company's instrumentation systems activity. The expansion is intended to enable the company to house in one facility all phases of its systems work and to house the headquarters of sales administration and sales support groups. . . . *The Boeing Co. has announced plans to construct a 100,000-sq.-ft. office and developmental support shop building in Huntsville, Ala. Some 800 of Boeing's 3,500 Huntsville employees will be housed in the building.*

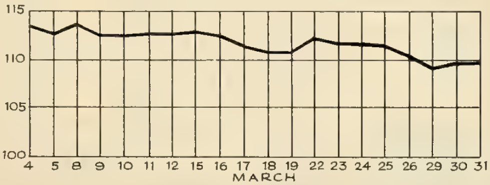
Mergers and Acquisitions

Robins Industries Corp., College Point, N.Y., has acquired Genarco, Inc., of Jamaca, N.Y. Genarco, a source of carbon arc solar radiation simulators, will be operated as a subsidiary of Robins. Robins manufactures data processing accessories and consumer electronic products. . . . *Planning Research Corp. of Los Angeles has reached a preliminary understanding on a plan whereby it would acquire all stock and assets of Mesa Scientific Corp., also of Los Angeles. Final acquisition is subject to agreement between the two firms, approval of their boards of directors, and approval of the shareholders of both corporations.* . . . Computer Systems, Inc., Richmond, Va., has reached an agreement whereby it will acquire most of the assets of Computer Products, Inc., Farmingdale, N.J. Final purchase is subject to court approval. Computer Systems has also announced the formation of a new subsidiary, Simulation Systems, Inc., which is to continue Computer System's specialization in the analog and hybrid computer field, manufacturing a full line of general purpose systems and components. . . . *Laboratory for Electronics, Inc., Waltham, Mass., has acquired the magnetostrictive delay line business of Ferranti Electric, Inc., Plainview, N.Y. Included in the acquisition is title to the basic patent for torsional magnetostrictive delay lines. Ferranti Electric is a subsidiary of Ferranti, Ltd., of Lancashire, England.* . . . Data Technology Corp. and KRS Electronics, Inc., have merged and will occupy the same plant in Mountain View, Calif. Both will function as a subsidiary of Datapulse, Inc., Inglewood, Calif. KRS will be known as the KRS Div. of Data Technology. KRS manufactures cartridge tape recorders for instrumentation, broadcast and professional use; Data Technology makes digital data instruments.

International

The Plessey Co. Ltd., British manufacturer of telecommunications equipment, is realigning its production groups. Aim is to increase the firm's share of the world markets. Operations will be organized into five self-contained product groups under the single name Plessey. They are: Automation; Components; Dynamics; Electronics and Telecommunications. . . . *Kawecki Chemical Co., Boyertown, Pa., has reached a licensing agreement with Imperial Chemical Industries, Ltd., England, concerning Imperial's new columbium alloy, SU 16. Kawecki will have exclusive manufacturing and marketing rights in the U.S. for the alloy, expected to have wide applications in the missile/space field.* . . . Fairchild Camera and Instrument Corp.'s Semiconductor Div. is establishing a manufacturing plant near Rennes, Brittany, France. The facility will employ 500 workers.

Missile/Space Stock Index



STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

AWARDS

AIR FORCE

$179,018,913—**North American Aviation, Inc.,** El Segundo, Calif., to manufacture components for the guidance, flight control and aerospace ground equipment of the improved *Minuteman* missile.

$16,200,000—**General Telephone and Electronics Corp.,** Sylvania Electric Products, Inc., New York City, for continued development of a ground electronics system to control targeting and firing of *Minuteman.*

$5,364,880—**Martin Marietta Corp.,** Littleton, Colo., for continued production of *Titan II* missiles.

$4,834,000—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for provision of *Agena-D* launch services at the Eastern and Western Test Ranges.

$2,300,000—**International Telephone and Telegraph Corp.,** Kellogg Communications Systems, Chicago, to engineer, furnish and install communications systems at Western Test Range.

$1,472,000—**Dynamics Corp. of America,** New York City, for equipment to be used in the Mediterranean Communications System.

$1,000,000—**Martin Marietta Corp.,** Denver, for work with the University of Denver on metals research.

$332,319—**Northeastern University,** Boston, Mass., for research and development of instrumentation to be flown on rockets and satellites for measurement of thermal and high energy plasma.

ARMY

$23,033,598—**General Dynamics Corp.,** Pomona, Calif., for engineering work and production of *Redeye* air defense missiles.

$8,907,548—**Raytheon Co.,** Bedford, Mass., for continued design and development of *Hawk* antiaircraft missiles.

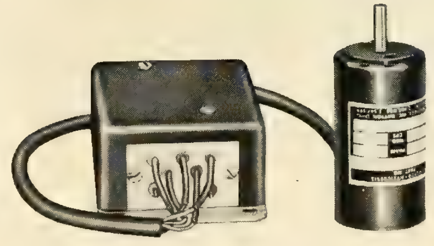
$38,052—**Thiokol Chemical Corp.,** Bristol, Pa., for redirection in method of nozzle manufacture under research and development program for design and delivery of an improved XM-33 rocket motor.

Ryan Aeronautical Co., San Diego, to continue providing *Firebee* target services at White Sands and McGregor missile ranges (amount not disclosed).

NAVY

$5,604,937—**Texas Instruments Inc.,** Dallas, for an oceanographic survey.

$329,067—**Radio Corp. of America,** Aerospace Systems Div. Van Nuys, Calif., for a classified program.



HOLD MOTOR SPEED TO 1%

with d.c. power in all environments

Maintain motor speed accurately to ±1% at temperatures fluctuating from −55° C to +75° C, at any factory set speed from 3,600 to 24,000 rpm, and with voltage fluctuating from 22 to 32 v.d.c. Globe's new frequency controlled d.c. to a.c. device combines all advantages of brushless d.c. operation with unusually precise 1% speed control over wide environment variations, and within 0.5% in a constant environment! Speed control weighs 10 ounces, measures 1 3/16" high x 2 1/4" wide x 3 1/4" long. Life can exceed 10,000 hours. Device has no moving parts or electrical contacts, and is designed to meet MIL-E-5272 for environmental protection. Fits many sizes of motors. Reverse polarity protection and transient voltage protection are available. Request Bulletin OPC. **Globe Industries, Inc., 1784 Stanley Avenue, Dayton, Ohio 45404.**

GLOBE

Circle No. 8 on Subscriber Service Card

$89,953—**General Electric Co.,** Heavy Military Electronic Dept., Syracuse, N.Y., for special study of the advanced surface missile system.

$49,627—**Thiokol Chemical Corp.,** Reaction Motor Div., Denville, N.J., for research and development of solid propellant exhaust gases.

Control Technology, Inc., Long Beach, Calif., for a 12-month study of the application of mathematical and computer techniques to control systems analysis (amount not disclosed).

NASA

$800,000—**Systems Engineering Laboratories, Inc.,** Ft. Lauderdale, Fla., for an electronic testing system to be used in conjunction with the *Saturn* space vehicle.

$500,000—**Douglas Aircraft Co., Inc.,** Missile and Space Systems Div., Santa Monica, Calif., for development of an improved shroud for use with the *Agena* space vehicle.

$37,420—**Trans-Sonics, Inc.,** Burlington, Mass., for special calibration and test equipment to be used in conjunction with the propellant measuring systems now being delivered to the *Saturn* program under a $2 million contract.

INDUSTRY

$4,900,000—**Lear Siegler, Inc.,** Santa Monica, Calif., from **General Electric Co.,** Mississippi Test Support Operation, Huntsville Ala., to provide instrumentation and control systems for NASA's Mississippi Test Operations.

$4,400,000—**Kaiser Aerospace and Electronics Corp.,** Oakland, Calif., from **Thiokol Chemical Corp.,** Wasatch Div., Brigham City, Utah, for production of thrust vector control nozzles for the first-stage solid propellant motors for *Minuteman.*

$4,000,000—**Goodyear Aerospace Corp.,** Akron, Ohio, from **Aerojet-General Corp.,** El Monte, Calif., to produce filament wound rocket motor cases for the first stage of the Navy's *Polaris A3* missile.

$2,903,000—**Ling-Temco-Vought, Inc.,** Military Electronics Div., Dallas, from **North American Aviation, Inc.,** Autonetics Div., Anaheim, Calif., for extended production of servo-actuators for *Minuteman I* and *II.*

$500,000—**International Telephone and Telegraph Corp.,** Cannon Electric Div., Los Angeles, from **Lockheed Aircraft Corp.,** Missiles and Space Co., Sunnyvale, Calif., for electrical connectors to be used in the *Polaris* missile program.

$380,000—**Tyco Laboratories, Inc.,** Waltham, Mass., from **Army, Navy, Air Force** and **NASA** for experimental studies on new electronics materials.

$184,654—**Radio Corp. of America,** Missile and Surface Radar Div., Moorestown, N.J., from **Massachusetts Institute of Technology,** Cambridge, for the PRESS program.

$56,655—**Radio Corp. of America,** Aerospace Systems Div., Van Nuys, Calif., from **McDonnell Aircraft Corp.,** St. Louis, for MX adapters.

$50,000—**Lockheed Aircraft Corp.,** Lockheed Propulsion Co, Redlands, Calif., from **McGill University,** Montreal, Canada, to produce two versions of a high-altitude research rocket for Project HARP.

DEFENSE ELECTRONICS SUPPLY CENTER

$50,189—**General Telephone and Electronics Corp.,** Sylvania Electric Products, Inc., Semiconductor Div., Woburn, Mass., for production of special semiconductor devices.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California 94035

Negotiations will be conducted with Barnes Engineering Co., for a radio-metric instrumentation system with radiation source. For information only; RFP not available.

Systems Engineering Group
Research and Technology Division
Wright-Patterson AFB, Ohio

RFP 516138-MA due April 12, 1965, in writing, for a theoretical study of the performance characteristics of the axisymmetric electrofluid dynamic (EFD) power generator being used in Aerospace Research Laboratories experiments.

Directorate of R&D Procurement
Systems Engineering Group
Research and Technology Division
Wright-Patterson AFB, Ohio

RFP 3239, due no later than April 13, 1965, for research on application of mathematical programming to approximation problems, digital computation encompassing non-linear constants, mixed integer solutions and non-simplicial methods.

Directorate of R&D Procurement
Systems Engineering Group
Research and Technology Division

RFP 516136, due no later than April 13, 1965, for contributive research in energy exchange processes between electric arcs, gas flows and magnetic fields. Work will be performed at the Aerospace Research Laboratories. Research and Development Procurement Office.

NASA'S NEW ELECTRONICS RESEARCH CENTER

A SPECIAL REPORT...

...to be published in MISSILES AND ROCKETS May 31, 1965 issue. The new center, although just entering the construction phase, has already issued RFP's to industry for electronics research contracts. The center which will eventually direct 50% of NASA's electronics research, has a FY '66 budget which already has reached $22 million, and by 1969 should reach $100 million.

More important, the Electronics Research Center will be in the forefront of NASA's drive to achieve the state-of-the-art advances in electronic systems and components required to carry out the sophisticated space missions planned in the late sixties and through the next two decades.

This report will provide in-depth analyses of Electronics Research Center's plans and programs, procurement policies, responsibility in electronic research and the construction schedule, costs and equipment for the individual laboratories.

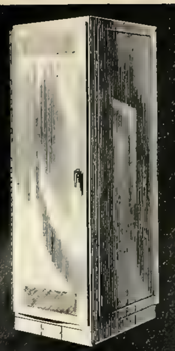
For companies marketing to NASA, this report offers a unique opportunity to reach the heart of the buying influences. Plan now to capitalize on this outstanding advertising opportunity.

Bonus Circulation: This issue of MISSILES AND ROCKETS will be delivered to every engineer, every designer, every scientist, and every management man at the Electronics Research Center. Copies will be made available to other Electronic Centers of NASA.

PUBLISHED: MAY 31 **ADVERTISING CLOSES: MAY 17**

missiles and rockets

the weekly of advanced technology



IN STEP WITH THE FUTURE . . .

ENCLOSURES FOR THE SPACE AGE!

Steel — Aluminum
- RFI Certified
- Heavy-duty
- Lightweight
- Stylized

What's your requirement?
Write for catalog-technical specs.

Amco ENGINEERING CO.

AMCO ENGINEERING CO.
7333 W. Ainslie St., Chicago, Illinois 60656

Circle No. 11 on Subscriber Service Card

let us move with you!

Six Weeks Is Required To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, **if possible, the address label from your last issue** . . . include your postal ZIP number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

◆ ◆ ◆

names in the news

MELLOR

ADAMS

RYAN

FERGUSON

James R. Mellor: Appointed vice president-advanced programs of the Data Systems division of Litton Industries. Also named at the same time were **Thomas E. Segar,** vice president-finance, and **Kenneth E. Walsh,** vice president-business management, for the Data Systems division.

Dr. Mac C. Adams: Elected director-at-large for the American Institute of Aeronautics and Astronautics for a three-year term. He is vice president and assistant general manager for Space Systems at Avco Corp.'s Research and Advanced Development Div.

Joseph C. Ryan: Named Washington, D.C., district manager of the Atomic, Defense and Space Group of Westinghouse Electric Corp. He succeeds **William Duncan** who has been appointed to the newly-created post of manager, aerospace programs, for the Aerospace Div. of Westinghouse Defense and Space Center.

Edward H. Ferguson: Named vice president-manufacturing at Nuclear Data, Inc. He will be responsible for production and all related activities for the firm, which manufactures multi-channel analyzers and signal averaging digital computers.

J. W. Wells: Elected vice president of Continental Aviation and Engineering Corp. He is also manager of the Washington office of Ryan Aeronautical Co.

Richard S. Anderson: Appointed vice president of Genisco Technology Corp. and general manager of Genisco Systems Div. He was previously general manager of the Data Div.

Kenneth M. Miller: Appointed vice president and general manager of Lear Jet Corp.'s Avionics Div.

James U. Blanchard: Elected vice president of Chicago Bridge and Iron Co. Also elected was **Sidney L. Luce** as a vice president.

Dr. Ralph A. Sawyer: Re-elected chairman of the Governing Board of the American Institute of Physics. He was formerly vice president and dean of the Horace H. Rackham School of Graduate Studies at the University of Michigan.

Paul E. Brunton: Promoted to vice president of the Guidance and Control Systems Div. of Litton Industries.

Gerald L. Smith: Received a $1,000 special service award for a computer analysis which resulted in a decision to give ground based navigation a primary role during *Apollo* lunar missions. He is a research scientist at NASA's Ames Research Center.

Dr. Norman Friedman: Named manager of the Lexington (Mass.) Dept. of System Development Corp.'s Defense Systems Div. He will be responsible for liaison and advance planning support for the Air Force's Electronic Systems Div. at Hanscom Field.

Jun Fukuzawa: Appointed programs manager for Sounding Rocket Technology at Inca Engineering Corp. He will administer plans, task teams, schedules, budgets and controls for development and fabrication of sounding rocket products.

John B. Williamson: Elected to the board of U.S. Polymeric, Inc. Also elected was **Gilbert E. Bezar.** Williamson is also a vice president and director of marketing.

Richard H. Fuller: Appointed operations manager of TRW Semiconductors Inc. He will be responsible for the functions of the plant managers.

Edward F. Lazar: Appointed director of technical services for Sperry Gyroscope Div. of Sperry Rand Corp. He will manage flight research, design, standards, publications, engineering and manufacturing services.

Bruce Schmitz: Joined Rocket Research Corp. as manager of rocket engine technology. He was formerly project engineer at the Jet Propulsion Laboratory, in charge of the hydrazine mid-course propulsion systems used in the *Ranger* and *Mariner* spacecraft.

Sidney B. Klein: Elected vice president-engineering of Simmonds Precision Products, Inc. He is also chief engineer at Simmonds.

—when and where

APRIL

Sixth Structures and Materials Conference, sponsored by the AIAA, Riviera Hotel, Palm Springs, Calif., April 5-7.

International Symposium on Fission Product Release and Transport Under Accident Conditions, sponsored by the Oak Ridge National Laboratory, Oak Ridge, Tenn., April 5-7.

Symposium on Advanced Propellant Chemistry, sponsored by AIAA and the American Chemical Society, Detroit Mich., April 5-7.

Symposium on High Energy Physics, sponsored by the Institute of Physics and The Physical Society (England), Birmingham, England, April 5-8.

International Symposium On Techniques of Memories, sponsored by the French Society of Electronics Technicians and Radioelectricians, Paris, April 5-10.

Third Navy Microelectronics Program Conference, U.S. Naval Postgraduate School, Monterey, Calif., April 6-7.

1965 Annual Region III Meeting of IEEE, Robert E. Lee Hotel, Winston-Salem, N.C., April 6-8.

IEEE Computer Technology Conference, Thunderbird Hotel, Los Angeles, April 6-8.

Dynamics of Defense Marketing, sponsored by the NDEI, Washington, D.C., April 6-8.

Aerospace Education Seminar-"Scientific Literacy in the Aerospace Age," sponsored by the Air Force Association, Cape Colony Inn, Cocoa Beach, Fla., April 8-9.

1965 International Exhibition of Electronic Components and First International Exhibition of Audio Equipment, Paris, April 8-13.

23rd Annual Meeting of the National Aerospace Services Assn., Washington Hilton, Washington, D.C., April 12-13.

Practical Aspects of Dynamic Programming, sponsored by the Detroit Research Co., Detroit, April 12-13.

Conference on Atomic Spectra and Radiation Processes, Oxford, Eng., April 12-14.

National Aeronautic Meeting and Production Forum, sponsored by the Society of Automotive Engineers, Inc., Sheraton-Park Hotel, Washington, D.C., April 12-16.

Pricing and Negotiating Prime and Sub-Contracts in the Defense and Aerospace Industries, sponsored by Contract Management Institute, The Columbia University Club, New York City, April 12-16.

Dynamics of Defense Marketing, sponsored by the NDEI, Los Angeles, April 13-15.

15th Annual National Telemetering Conference, sponsored by the IEEE, ISA and AIAA, Shamrock-Hilton Hotel, Houston, April 13-15.

1965 Annual Region VI Conference of the IEEE, Las Vegas, April 13-16.

Advanced Planning Briefings for Industry, sponsored by DOD and NSIA, Marriott Motor Hotel, Dallas, April 14-15.

1965 Electronics & Instrumentation Conference and Exhibit, sponsored by ISA, Cincinnati Gardens, Cincinnati, April 14-15.

Specialists Conference on Thin Film Action Devices, sponsored by Johns Hopkins University, Baltimore, April 14-15.

New Horizons in Computation, sponsored by the Association for Computing Machinery, Marriott Twin Bridges Motor Hotel, Arlington, Va., April 15.

International Conference on Programming and Control, sponsored by the Air Force Office of Scientific Research and the University of California, U.S. Air Force Academy, Colorado Springs, Colo., April 15-16.

Symposium on Human Physiological and Performance Determinants of Manned Space Systems Design, sponsored by the American Astronautical Society and the Human Factors Society, California State College, San Fernando, Calif., April 15-16.

International Conference on the Mechanics, Physics and Chemistry of Solid Propellants, sponsored by the Office of Naval Research and Purdue Univ., Purdue Univ., Lafayette, Ind., April 19-21.

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Paris, France—11 Rue Condorcet; TRU 15-39

Advertisers' Index

AEROJET-GENERAL CORP. 48
Agency—D'Arcy Adv. Co.

AMCO ENGINEERING CO. 44
Agency—Harris D. McKinney, Inc.

ATLAS CHEMICAL INDUSTRIES, INC., AEROSPACE COMPONENTS DIV. 11
Agency—Harris D. McKinney, Inc.

BECKMAN INSTRUMENTS, INC. 40
Agency—Erwin Wasey, Inc.

BOEING AIRPLANE DIV. 27
Agency—Forbes, Inc.

CONTROL DATA CORP. 2
Agency—Klau-Van Pietersom-Dunlap, Inc.

DORNE & MARGOLIN, INC. 4
Agency—Snow & Depew Adv., Inc.

DOUGLAS AIRCRAFT CO., INC. 5
Agency—J. Walter Thompson Co.

EITEL McCULLOUGH, INC. 38
Agency—Cunningham & Walsh, Inc.

FAIRCHILD HILLER, STRATOS DIV. 10
Agency—S. G. Stackig, Inc.

GLOBE INDUSTRIES, INC. 42
Agency—Odiorne Industrial Adv., Inc.

HONEYWELL, DENVER DIV. 34
Agency—Campbell-Mithun, Inc.

LOCKHEED MISSILES & SPACE CO. 18
Agency—Hal Stebbins, Inc.

MARTIN CO. 25
Agency—Ketchum, MacLeod & Grove, Inc.

NORTH AMERICAN AVIATION, INC. . . 8
Agency—Batten, Barton, Durstine & Osborn, Inc.

SPACE TECHNOLOGY LABS., A SUB. OF THOMPSON RAMO WOOLDRIDGE, INC. 6, 39
Agency—Fuller & Smith & Ross, Inc

J. P. STEVENS & CO., INC. 17
Agency—McCann-Erickson, Inc

VARIAN ASSOCIATES 47
Agency—Hoefer, Dieterich & Brown, Inc.

Fun and Games

ONE OF THE MOST QUALIFIED and professional writers in the missile/space field is Mr. William Hines of the Washington *Evening Star.* Last week, he turned out an interpretive piece which so well expresses our own sentiments that we want to quote from it liberally. Mr. Hines has said it as well as it can be said.

"The case of Gus Grissom and the bologna sandwich," he wrote, "points up a problem scientists are having with the astronauts, some of whom adopt the stance of the fun-loving Rover in regard to peripheral aspects of their flight.

"Like the good test pilots they are, the astronauts insist on checking out their machine carefully before taking off and reducing the number of chances they take to an absolute minimum. There are old pilots and bold pilots, but no old, bold pilots, and the astronauts know this.

"But some of the scientific things they are supposed to do leave them cold. The same is true of some of the strictly engineering data they are supposed to gather.

"It turned out after last Tuesday's flight that John Young, as a gag, brought aboard the 'Molly Brown' a sandwich for his partner, Grissom. (It was actually a corned-beef sandwich, but has now become immortalized in space-age lore as a bologna sandwich because of a question asked at the astronauts' news conference Thursday.)

"Grissom ate the sandwich, or part of it—a fact to which one might react, 'So what?' The so-what about it is that by eating while in flight, Grissom compromised what might otherwise have been useful medical data.

"Young was supposed to eat some special *Gemini*-type food, and Grissom was not supposed to eat. Scientifically, Young could be described as the subject of a food-eating experiment and Grissom as the control. The use of controls in experiments has been standard practice in science since the 16th century.

"No one is suggesting that Grissom was sick after landing because he ate the 'bologna sandwich.' Dr. Charles A. Berry, head astronaut medic, predicted the Sunday before the flight that if 'Molly Brown' had to remain afloat long after landing, one or both of the pilots would become nauseated.

"The distress over minor clowning by the astronauts arises from the fact that each space flight is terrifically expensive and at best only scantily productive of new information. Even by the space agency's own conservative estimate, the *Gemini-Titan 3* flight last Tuesday cost $45 million. One could, with justification, double this as the true figure.

"To disrupt even a marginal piece of data that might come out of a $45 (or $90) million flight is, in the view of the scientists, a serious matter . . ."

The Washington *Star* reporter suggests that one reason for the carefree attitude of some of the astronauts is the head-turning publicity showered upon them and the limelight given them by the magazine contracts they share.

If our past experience is any measure, Mr. Hines is in hot water with a number of irate readers who believe the astronauts are above such criticism. We intend, however, to join him in the pot.

We are well aware that military pilots in general, and test pilots in particular, are a happy-go-lucky lot who take their fun where they can find it. But the great majority of them, as with the majority of the astronauts, are all business when they step into the cockpit of an expensive flying machine.

The case of the "bologna sandwich" and the somewhat flippant attitude toward the sea urchin experiment suggest that Grissom and Young perhaps were not as impressed with some of the serious scientific aspects of the flight as they might have been. It certainly is easy to understand their exuberance merely at surviving such a hazardous undertaking as a spacecraft launch. It is also easy to understand the carefree attitude of derring-do pilots toward those stodgy old scientists who stay on the ground. But to understand these things is not to condone them. And we must agree wholeheartedly with the comments of Mr. Hines.

For a reason why, we need look no further than the remarks of Rep. George Miller (D-Calif.), chairman of the House Science and Astronautics Committee, to an Aero Club luncheon in Washington last week. Discussing the manned space program, Mr. Miller said:

"We do these things not as stunts. This is not sitting on top of a flagpole or seeing how many people can crowd into a telephone booth. This is for the betterment of America and of mankind."

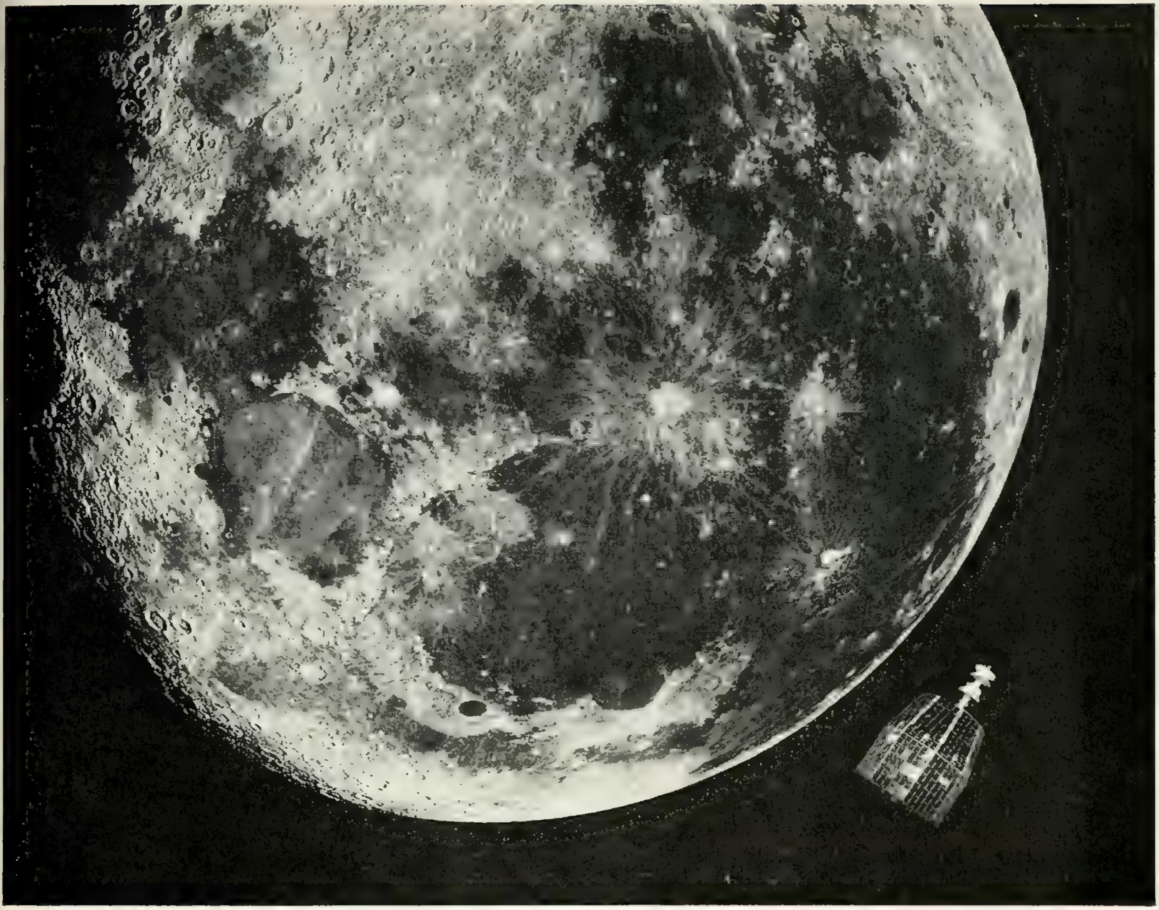
WE SUGGEST that the two *Gemini* astronauts, after the parades are over, could do worse than give some sober reflection to the comments of the California Congressman.

We are all in favor of fun and games and lighthearted jokes. Not for a minute would we suggest that the astronauts should be a gloomy long-faced crew. But we do believe that when the fun and games interfere with the scientific aspects of space flights for which American taxpayers are shelling out considerable amounts of money, then it is time to knock them off.

The press must share part of the blame for this. The astronauts have been so thoroughly lionized that it is surprising that they have remained as levelheaded as they have. We have expressed ourselves in the past on the subject of the magazine contracts and won't go into that again.

These men are carefully selected and thoroughly trained. We have every right to expect their behavior to be exemplary. Perhaps the data compromised by that "bologna sandwich" were not very important. But the question of attitude is. And it left something to be desired on *GT-3.*

William J. Coughlin



U.S. AIR FORCE

VARIAN POWERS
LEAP FROG
OVER-THE-HORIZON
COMMUNICATIONS

Leap Frog, a project of the USAF Avionics Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio, is a microwave communication program which will provide a flying laboratory to investigate real time long range microwave communication techniques which can be applied to future Air Force weapon systems development.

Two-way communication links will be established between the airborne terminal and ground stations via active satellites and passive reflective media in space to achieve the extended range not now available in air/ground microwave systems. A Varian VA-863 Power Amplifier Klystron will provide an average power of 10 kW CW at X band in the airborne transmitter.

Project Leap Frog is one more example of Varian's ability to power the world's most advanced microwave systems.

VARIAN associates
TUBE division

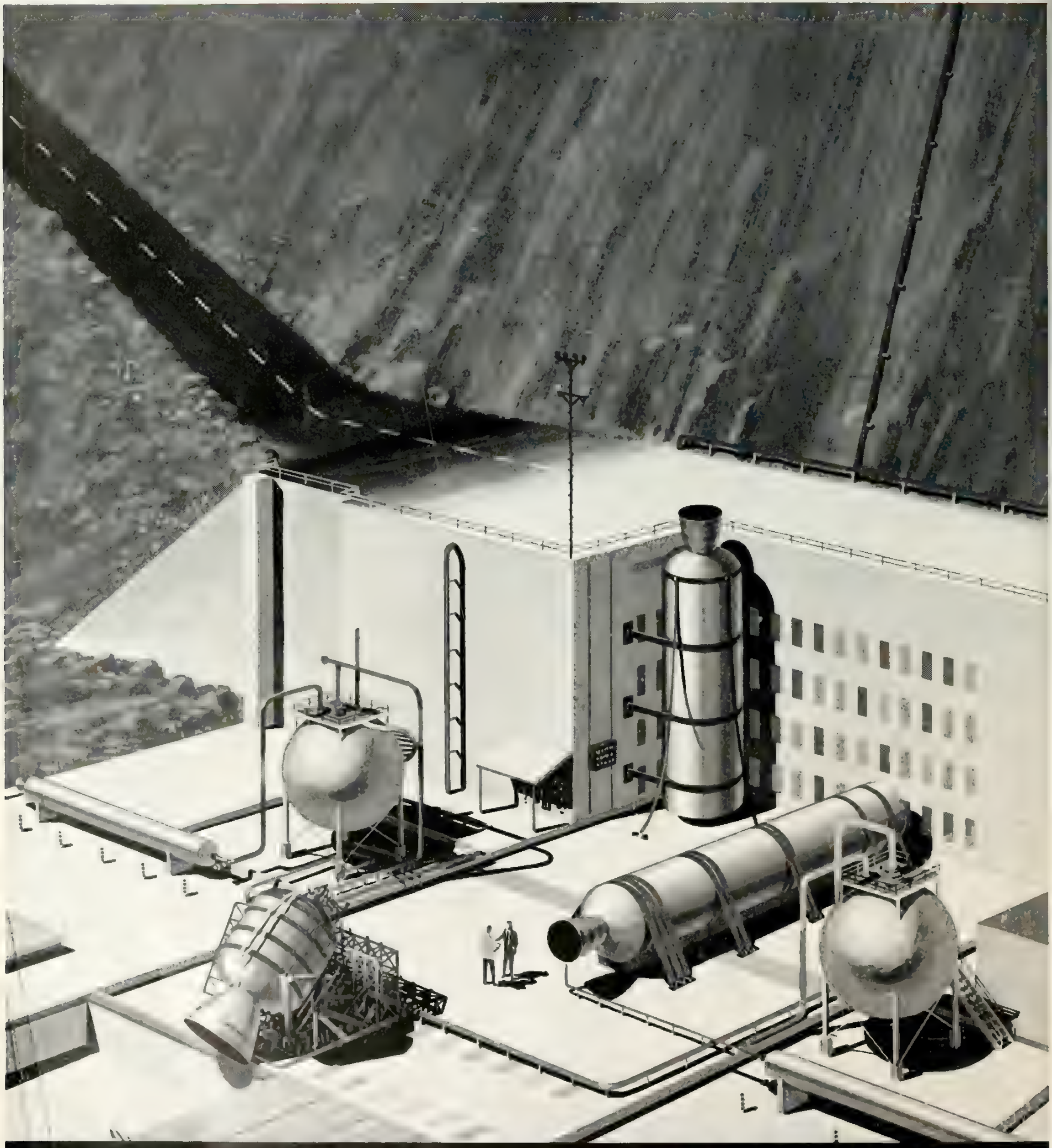
Executive Offices: 611 Hansen Way, Palo Alto 10, Calif. ☐ Microwave Tube Group: Palo Alto Tube Division ☐ Solid State Products ☐ Bomac Division ☐ SFD Laboratories, Inc. ☐ Varian Associates of Canada, Ltd. ☐ In Europe: Varian A.G., Zug, Switzerland

Circle No. 9 on Subscriber Service Card

TRIPLE THRUST Anchored fast to a Mojave mountain—a unique complex for test-firing solid rockets vertically and horizontally. Liquid engines horizontally . . . cryogenic or storable propellants. Complex now under construction at Edwards Air Force Base. Designed by AETRON for the U.S. Army Corps of Engineers, Los Angeles District.

AETRON®
Covina, California / A Division of Aerojet-General Corporation

GENERAL TIRE ™



ARCHITECTURE · ENGINEERING · INSTRUMENTATION · FABRICATION · CONSTRUCTION MANAGEMENT

APRIL 12, 1965

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

APR 1965
HOUSTON PUBLIC
LIBRARY
Houston, Texas

TRW/STL Comsat Entry Goes Into Simulator

Early Bird Operations May Be Speeded

House Group Asks LBJ for MOL Ruling .

Ranger Evaluation Report—Part II . . . . .

TION

UNITED STATE
15

Careers on the move in **propulsion**

The direction is "up" for both the many Douglas space vehicles and the careers of the men involved in providing the boost that gets them into orbit or beyond.

In particular, Douglas is seeking engineers and scientists qualified in propulsion disciplines for such programs as Delta, Zeus, manned spacecraft, Saturn S-IVB and manned orbiting laboratories.

Please send your resume to Mr. I. S. Snodgrass,

DOUGLAS

MISSILE AND SPACE SYSTEMS DIVISION
2700 Ocean Park Blvd., Santa Monica, Calif.
An equal opportunity employer

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 15 April 12, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors

Charles D. LaFond	Electronics
William S. Beller	Engineering

Associate Editors

Lawrence J. Curran	Assistant Managing Editor
Heather M. David	Space Medicine
Michael Getler	Electronics
John F. Judge	Propulsion/Materials
Robert L. Parker	Copy Editor
Rex Pay	Electronics
Hal Taylor	NASA
James Trainor	Military
Donald L. Zylstra	Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach	Art Director
Donald Strickland	Assistant Art Director
Suzanne Montgomery	Editorial Assistant
Sally Fosnight	Editorial Assistant

BUREAUS

LOS ANGELES.....9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks.....Bureau Chief
NEW YORK.....20 East 46th Street
Michael Getler
CAPE KENNEDY.....507 Orange Ave.
Merritt Is., Fla.
MIDWEST.....423 N. Quentin
John L. Zimmerman.....Wichita, Kan.
PARIS.....11 Rue Condorcet
Jean-Marie Riche

EDITORIAL ADVISORY BOARD

Dr. Peter Castruccio
Alexander Satin
Conrad H. Hoeppner
Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton	National Sales Manager
Paul B. Kinney	Eastern Advertising Manager
Edwin J. Denker, Jr.	Western Advertising Manager
Kenneth C. Blanchard	Marketing & Research Director
John N. Carlin	Director of Circulation
Paddy Nelson	Circulation Promotion
R. Virgil Parker	Director of Production
Barbara Wiener	Advertising Services Manager

Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President	Wayne W. Parrish
Senior Vice President	Louis C. James
Vice President	Fred S. Hunter

AUDITED PAID CIRCULATION ABC

ABP

THE COVER

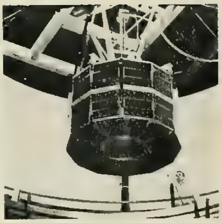


PHOTO BY ROBERT W. YOUNG

TRW Space Technology Laboratories' entry in Comsat Corporation communications satellite contest is shown being lowered into a space environment simulator. Early Bird, Comsat's preliminary operational-experimental satellite, was sent into Earth orbit April 6. See page 12.

APRIL 12 HEADLINES

SNAP 10A T/M Noise Obscures Ion Engine Data 10
NASA Awards Study Pacts for X-15 Ramjet 10
Comsat Corp. May Accelerate Operational Early Bird .. 12
SNAP 10A First Nuclear Power Plant in Space 13
Go-Ahead Expected Soon on Uprated Atlas Booster .. 14
GT-6 Scheduled To Rendezvous During Third Orbit 14
Senate Authorizes $15.28 Billion for DOD in FY '66 .. 15
OAO, OGO and Surveyor Due for Possible Cuts 15
Space Committee Seeks MOL Ruling from LBJ 16
Plane in Chinese Photos Apparently Firebee Drone .. 17

LUNAR EXPLORATION

Successful Rangers Located Lunar Landing Sites 22

MATERIALS

Wound Tungsten Affords New Structural Shapes 27

SPACE MEDICINE

Air Force Studying Toxic Effects in Space Cabins 28

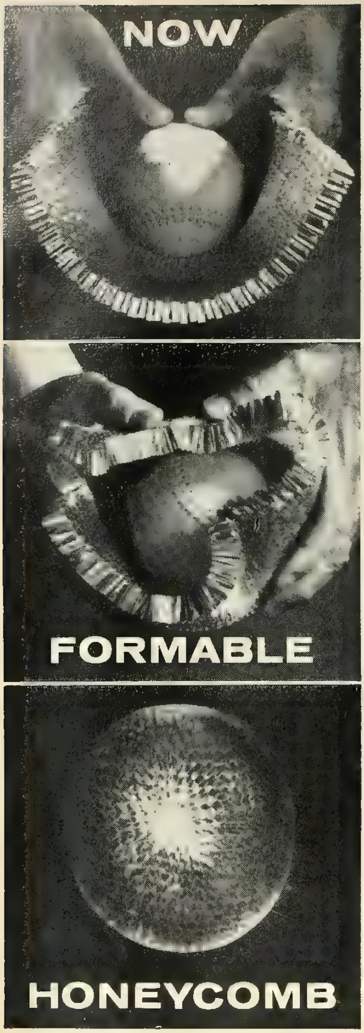
SPACE SYSTEMS

Satellite Serves as Geodetic Mapping Benchmark 33

DEPARTMENTS

Letters 4
The Countdown 7
The Missile/Space Week® 10
Technical Countdown .. 21
The Industry Week 37
Contracts/Procurements 38
Names in the News .. 44
When & Where 45
Editorial 46

47,900 copies this issue



Hexcel FLEX-CORE® For Complex Shapes

A new form of aluminum honeycomb—designed to solve core forming problems for tightly curved sandwich sections—cones, cylinders, spheres, leading edges, almost any simple or compound curved structure where high strength-to-weight is important.

FLEX-CORE is available in 5052 aluminum alloy in densities of 2.1, 3.1, 3.7, 5.7, 7.1, 9.0 lbs./cubic foot. FLEX-CORE is one of numerous new specialized honeycomb materials from Hexcel.

For descriptive literature, call or write to:

HEXCEL® PRODUCTS INC
World leader in research and manufacture of honeycomb core materials.

Executive Offices: 2332C Fourth St., Berkeley 10, California, (415) 843-4664

Sales Offices: Inglewood, California, (213) OR 8-4121; Havre de Grace, Md., (301) WE 9-2900; Irving, Texas, (214) BL 3-4174

Circle No. 1 on Subscriber Service Card

letters

'This High Man'

To the Editor:

Please accept my warmest thanks for the perceptive and sympathetic editorial which you wrote for the March 22 issue of MISSILES AND ROCKETS.

What you say about the fate of a present-day dreamer struck a responsive chord here. As I have said on many occasions, the honors that have come to my husband in the twenty years since his passing border on the legendary. I cannot help hoping that he knows; if he does, he must be deeply pleased.

Esther C. Goddard
(Mrs. Robert H. Goddard)
Worcester, Mass.

Astronauts' Fun

To the Editor:

Congratulations on your outspoken yet balanced criticism of "astronautic fun" (editorial, April 5). It's sure to help. I still love and appreciate our astronauts, but I'm "in the pot" with you.

I continue to enjoy and profit from M/R, especially from the coverings of recent *Ranger* findings and space technology.

Paul Grout, S.J.
Saint Louis University
St. Louis, Mo.

More Basic Moon Work

To the Editor:

The excellent performance of *Ranger IX* is but another step and there is much more work to be done prior to the establishment of a base on the Moon.

Oxygen is the commonest substance on our planet Earth; hydrogen is the commonest substance in all of the Universe; and the heating of a metal in the presence of vapor or steam results in the formation of a metallic oxide that is heavier than the original metal plus the release of free hydrogen.

Some metals lose or gain weight when converted from one form and/or environment into another form and/or environment, which accounts for the loss of the weight of metals in orbiting satellites.

Air Force studies indicate that the muscles of orbiting astronauts may lose tone and strength from loss of nitrogen and sulfur because of environmental molecular displacements as aforementioned, therefore necessitating closed-force-loop tools and implements wherein a to-and-fro vibratory movement across a point of equilibrium provides momentum in a field of weightlessness; and whereby a nut, bolt or tube, etc. will be actuated upon the tangential application of such a vibrating implement to the periphery of the said nut, bolt or tube, etc.

Much basic work is required in our rapidly accelerating exploration of outer space.

Harry Bricker Fuchs
Farmingdale, N.Y.

Annual DOD Issue

To the Editor:

The Fourth Annual DOD Issue has just landed on my desk and I've had time only to read your editorial and look over the table of contents, but the magazine is going home with me for the weekend for a thorough reading from cover to cover. It is interesting to see the variety of contents, and inasmuch as your articles are always expertly written I look forward to reading them.

Stuart D. Golding
Vice President
Arthur Schmidt & Associates, Inc.
New York, N.Y.

To the Editor:

I read your March 29 issue with a great deal of interest. Many of the articles in this issue contain information pertinent to work in which we are keenly interested.

Fernley G. Smith
Assistant to Vice President
Manager of Ordnance
TRW Jet & Ordnance Division
Thompson Ramo Wooldridge Inc.
Cleveland, Ohio

To the Editor:

I want to thank you for a most illuminating Annual DOD Issue containing much fresh and comprehensive material on the most timely subject of tactical R&D for Defense. You have made a real contribution both to the missile/space industry and to the military effort.

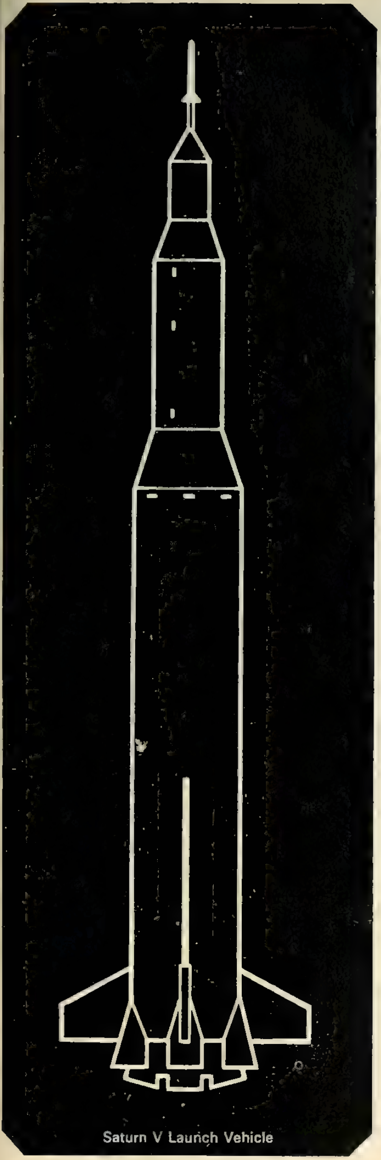
Walter Carmichael
Chicago, Ill.

Additional Copies Of Missiles and Rockets' Annual DOD Issue

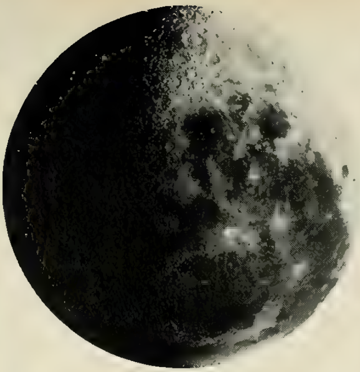
Extra copies of MISSILES AND ROCKETS' *annual DOD issue, published March 29, may be purchased from:*

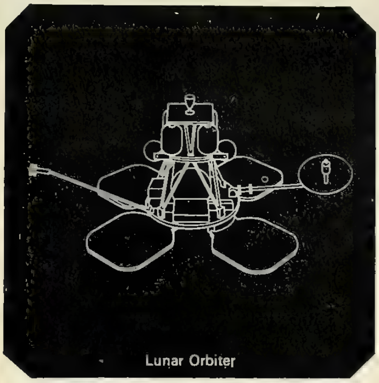
Research Department
Missiles and Rockets
1001 Vermont Avenue, NW
Washington, D.C. 20005

Price per copy is $1.00. Bulk prices upon request. Payment must accompany order.



Saturn V Launch Vehicle

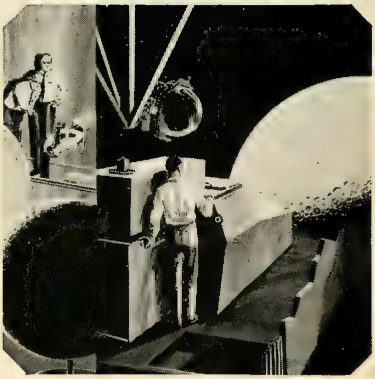




Lunar Orbiter

Minuteman ICBM

Space-Age Boeing Openings



Space Research

for Engineers and Scientists

The Boeing Company's Aero-Space Division, major contractor for the Saturn V launch vehicle, Minuteman ICBM and the lunar orbiter, has a number of challenging opportunities for graduate engineers and scientists. (See list in right-hand column.) Assignments, which vary with each Boeing facility, are at Cape Kennedy, Fla.; Huntsville, Ala.; New Orleans, La.; Seattle, Wash., and Vandenberg AFB, Calif.

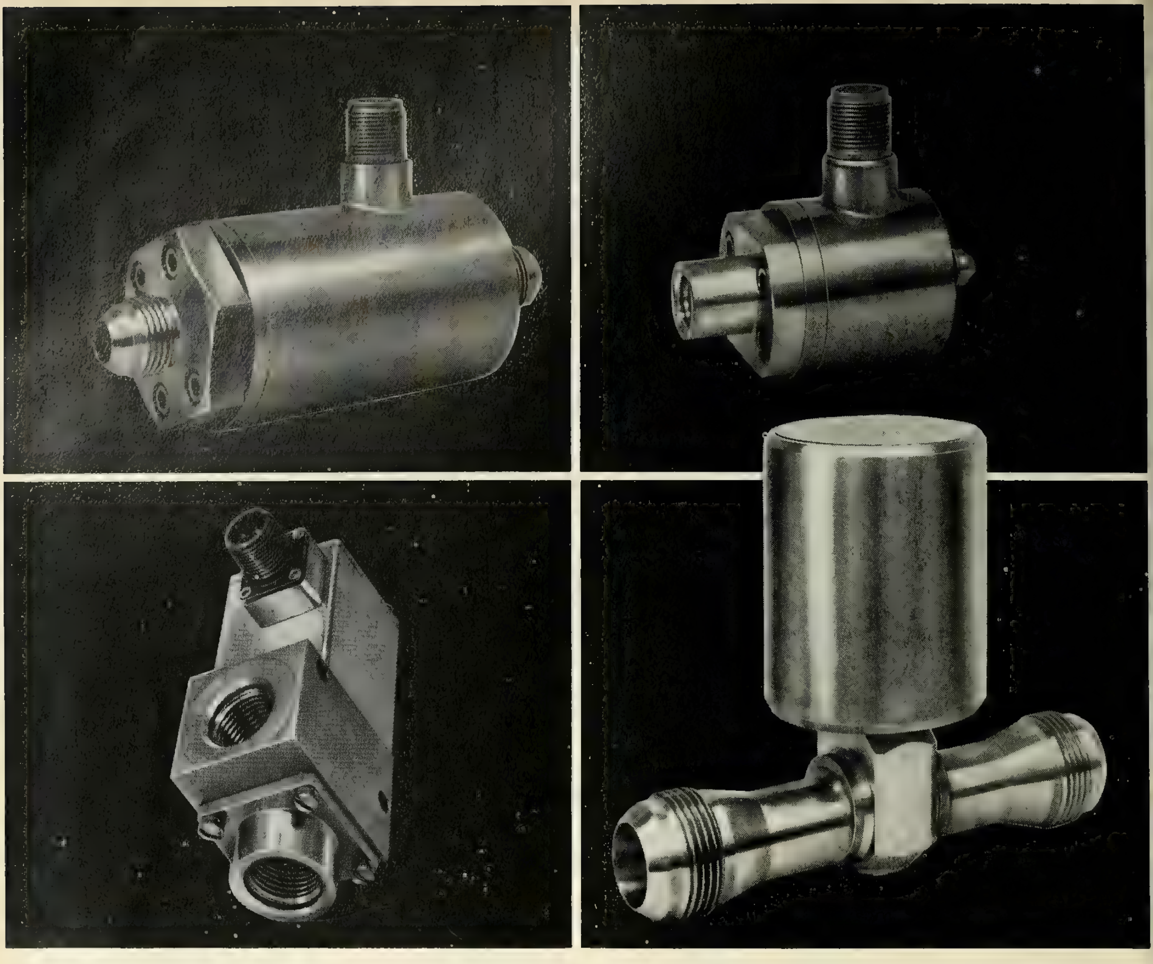
Minimum requirements are a B.S. degree in an engineering or science discipline, plus applicable experience. Salaries are commensurate with your experience and education background. Travel and moving allowances are paid to newly hired personnel. Boeing is an equal opportunity employer.

Send your resume today to the employment manager at the installation(s) you prefer: Mr. L. S. Bonsteel, Boeing Atlantic Test Center, P. O. Box 1698 - MSZ, Cocoa Beach, Fla.; Mr. John Hall, Boeing Launch Systems Branch, P. O. Box 1680 - MSZ, Huntsville, Ala.; Mr. L. Wendell Hays, Boeing Launch Systems Branch, P. O. Box 29100 - MSZ, New Orleans, La. 70129; Mr. John H. Taylor, Boeing Pacific Test Center, P. O. Box 1626 - MSZ, Vandenberg AFB, Calif., or Mr. Lawrence W. Blakeley, The Boeing Company, P. O. Box 3822 - MSZ, Seattle, Wash. 98124.

Systems Engineering • Flight Technology • Telemetry Systems and Design • Electronics Technology • Instrumentation • Propulsion and Mechanical Systems • Scientific Computer Programming • Logistics Engineering • Aerospace Program Planning • Metallurgy • Test Engineering • Electrical/Electronic Design • Materials & Processes • Human Engineering • Cryogenics • Weights Engineering • Guidance & Control • Reliability • Service Engineering • Mechanical Design • Structures Analysis & Design • Computer & Logic Circuit Development • Industrial Engineering • Electronic/Electromechanical Parts Evaluation • Computer Systems Analysts

BOEING

Divisions: Airplane • Turbine • Vertol • **AERO-SPACE** • Also, Boeing Scientific Research Laboratories



100% s/s valves for Hydrazine, Hydrogen Peroxide, N_2O_4, Fluorine and Triethylaluminum

Here's high reliability in solenoid valves for exotic aerospace fuels and slurries. All stainless steel construction contains no internal plating—eliminating the dangers of "flaking".

These are not "paper" designs, but production valves proven by extensive field usage. All welded construction gives mass spectrometer tightness—and absolute safety. Available in several types: coaxial, poppet, angle body and patented Valcor Floating Seal principle. Line sizes from ¼" to ¾". Pressures to 3000 psig. Lightweight and compact with large capabilities—and high reliability. May we send you more information? Write today to:

Valcor Engineering Corporation
5362 Carnegie Ave., Kenilworth,
New Jersey.

VALCOR
SOLENOID VALVES

Circle No. 2 on Subscriber Service Card

The Countdown

WASHINGTON

Nuclear Rocket Funding Expected in '67

NASA officials now believe that a start will be made on a nuclear rocket flight test project in the FY '67 budget. Target date for the flight would be the mid '70's. Rockets would be powered by the Phoebus reactor and the Nerva II nuclear rocket engine. Aerojet-General Corp., which is developing technology in the Nerva engine program, is regarded as a sure bet to be selected for Nerva II development. Funding, if approved, will be devoted primarily to the reactor and engine, with less attention to the flight vehicle itself.

First STINGS Flight Due This Week

First flight test of STINGS, the stellar-inertial guidance system developed by General Precision, Inc., is set for Tuesday night or Wednesday morning. System will be launched from the Eastern Test Range aboard a *Polaris A-1* missile.

Humphrey To Meet with Space Council

Vice President Humphrey chairs his first National Aeronautics and Space Council meeting this week. Staff members, meanwhile, are busy scheduling trips to NASA's Manned Spacecraft and Marshall Space Flight Centers in an effort to complete his space education as rapidly as possible.

House May Clear Missile/Space Bills Fast

The House is trying to schedule passage of all of its missile and space bills before June. The authorization bills are almost ready for floor presentation. The Appropriations Committee has set May 6 as the deadline for reporting out its Independent Offices bill (NASA), May 10 for Public Works (AEC) and May 13 for Defense.

Army Seeks Hardened Nike-X Study

Army has asked General Electric to submit proposals on a study of a hardened *Nike-X* system. Proposal was solicited by the *Nike-X* project office. Competition was precluded because of urgency of the procurement and GE's experience with Project Defender.

Athena Launches To Be Resumed

Following a one-month halt for range support review, *Athena* launches are to be resumed this month from Green River, Utah, to White Sands Missile Range. Review, called for by the range, is understood to have resulted in a five-degree widening of the launch corridor. Launches are expected on a three-a-month schedule until the planned 77 firings are completed. Twelve launches were made before the program was halted last month. Prime contractor is Atlantic Research Corp.

Marshall Looks at Recoverable Boosters

Marshall Space Flight Center has proposed a new study of recoverable booster concepts which calls for possible use of a *Titan I, Redstone* or *Little Joe II* in a project to test recoverable techniques. No decision on the plan has been made by the Office of Manned Space Flight and some officials are predicting its future is gloomy. NASA currently is more interested in a reusable transportation system than just a recoverable booster.

Voyager Isotopic Unit Is Planned

NASA will develop an isotopic thermoelectric power unit for the *Voyager* program, starting with the FY '67 budget. Discussions currently are under way between the space agency and Atomic Energy Commission on the reactor to be used to power the conversion unit. It is expected to be in the 250-to-300-watt power range and will be used to supply power to the *Voyager* landing capsule.

Go-Ahead Given for Lunar Rover

NASA has decided to go ahead with development of a simple roving vehicle for the last few *Surveyor* spacecraft in the Block II series. The vehicle is expected to weigh 100 lbs. or less. It would be employed to test lunar surface bearing strength under the watchful eye of a TV camera. Cost is estimated at a minimum of $30 million. NASA may have to curtail its plans somewhat, however, since the House Space Committee is considering a cutback in *Lunar Rover* funds until at least one *Surveyor* is successful (see page 15).

Pegasus B Due at Cape This Week

Pegasus B spacecraft is to be delivered at Cape Kennedy on Monday. It is scheduled for a late-second-quarter launch aboard the first firing of a Chrysler-built *Saturn I*.

NASA Considers Supplemental Request

The space agency is considering request of a supplemental FY '66 authorization for use as an *Apollo* contingency fund. Rep. Olin Teague (D-Tex.), chairman of the Manned Space Flight Subcommittee, supports such a move. But there is doubt it would have Administration support.

INDUSTRY

Hardy Takes Look at Aerospace Corp.

Rep. Porter Hardy (D-Va.), chairman of the House Armed Services Investigation Subcommittee, paid a visit to Aerospace Corp. facilities at El Segundo and San Bernardino, Calif., last week. With him was Rep. Otis G. Pike (D-N.Y.), a member of the subcommittee. The trip was part of an investigation of corporation practices in advance of hearings scheduled to open late this month.

Douglas To Build More Thors

Air Force has ordered 28 *Thor* space boosters from Douglas Aircraft at a cost of some $13 million. Production, to begin this year, will continue into 1966. It is anticipated that the boosters will be used in the classified *Discoverer* program as well as for carrying other Air Force and NASA scientific payloads.

INTERNATIONAL

A Bird in Hand

Future of an international communications satellite under study in West Germany hinges on the success or failure of Comsat Corp.'s efforts to deploy an operational communications satellite network. Dr. Eugen Knoernschild, director of the Stuttgart Center of the German Experimental Institute for Air Travel (Deutsche Versuchsanstalt der Luftfahrt) says studies conducted by his organization will be discontinued if Comsat Corp. fulfills its mission. With *Early Bird* performing well in the early phases of its mission, chances of the German concept reaching the hardware stage are dim.

British May Buy F-111

Britain's cancellation of the TSR-2 program opens the door for possible purchase of the U.S. F-111 and its weaponry. Dept. of Defense is prepared to make the F-11 available.

Some missiles are lucky— hey know where they are, hey know where they're going, and sometimes they have a star to guide them.

We're constantly working to improve the luck of missiles.

We work with incredibly tiny, reliable circuits for nertial guidance systems—putting electronics and hardware into the same package where they'll be safer and still more reliable.

We're deep in accelerometer designs that are equally sensitive to high g's and the gentlest of thrusts.

We're developing a nuclear gyro based on an isotope of mercury. And laser gyros that compare intense beams of coherent light.

But our interest in sensing elements is only a means to an end. These components together with computers are tied into systems that become the nerves and brains of missiles, aircraft, and space vehicles.

For example, General Precision is working under a U.S. Air Force contract on a program covering the development of a new-generation stellar/inertial guidance system (STINGS), integrating it into a test vehicle and administering the flight tests. We've also studied the problem of accurately guiding a missile which is launched from a mobile vehicle and is completely independent of ground control after launching.

A low-cost inertial guidance system, the heart of which is a radically new approach to gyro design, is scheduled for flight testing. Weighing only 20 pounds, it includes a solid-state computer making extensive use of integrated circuits.

In addition to missile and space vehicle control, General Precision scientists and engineers are working on advanced navigation systems for manned aircraft. A new Doppler radar navigation system using microelectronic circuitry is under development. Its light weight and low cost will make it practical for every type of aircraft. In current production are Doppler navigation radars for Navy and Air Force aircraft, the major portion of the guidance system for SUBROC, the guidance computer for Centaur, and navigation computers for the A4E and C-141 aircraft.

General Precision is a primary source of experience for programs involving technological teamwork at the highest levels. Our work in the aerospace and military fields is well known. We will be pleased to show you how our capabilities can fit in with your needs in high-precision electronic areas—navigation, guidance & control; simulation; radar; digital information systems including command & control and communications equipment; weapons fire control; and data processing. General Precision, Inc., Tarrytown, N.Y.

GP GENERAL PRECISION INC.

Circle No. 3 on Subscriber Service Card

The Missile/Space Week

Noise Obscures Ion Engine

The Air Force reported last week that an unexplained "extremely high noise factor" in telemetry received from SNAP 10A (see p. 13) made it impossible to determine whether the ion engine aboard the same spacecraft was operating.

Space Systems Div. reported that during the time the engine was supposed to be on, this noise factor is introduced in the telemetry, and disappears when the engine is supposedly turned off. Since telemetry received is "unintelligible" during the supposed engine operation an Air Force spokesman said, "we cannot positively confirm either successful operation of the ion engine or failure to operate."

Because of the possibility that operation of the engine, which appears to produce the noise, "may also have a degrading effect on the primary experiment—operation of the SNAP 10A system—further analysis is necessary before any decision can be made to continue periodic tests of the ion engine.

"Detailed analysis of the information stored in the on-board tape recorder of the SNAP *Agena* vehicle is continuing. Telemetry indicated that on receipt of the ground command to start the ion engine: 1) the heating element in the cesium reservoir came on; 2) the cesium vaporized; 3) the cesium valve operated as planned; 4) the ionizer heated up; 5) there was positive indication that the ion beam was drawing current when high voltage was turned on.

"At this point, which coincides with the time when the engine would begin operation, an extremely high noise factor was introduced in the telemetry."

As of April 7, there had been only one attempt to operate the engine.

SSD said the procedure is to turn the engine on by command and run it for one hour, after which it is automatically turned off by a timer. Then 30 hours are allowed for the battery to recharge.

AFSC Gets Atlas Job at VAFB

Responsibility for all checkout and launch of *Atlas* missiles at Vandenberg AFB, Calif., has been taken over from the Strategic Air Command by the Air Force Systems Command.

The change is a logical result of the phaseout of all *Atlas* missiles from SAC's operational inventory, Air Force spokesmen said. AFSC will conduct all future Western Test Range launches in support of the Army *Nike-X* program and the Air force *ABRES* effort.

NASA Issues Ramjet Studies

NASA has selected three aerospace firms to prepare preliminary designs for a hypersonic ramjet research engine.

Chosen April 5 to make the parallel studies were: Garrett Corp., General Electric Co., and Marquardt Corp. Each firm will receive about $500,000 for its study.

Each company will conduct a detailed study of advanced ramjet engine technology to define the best possible research engine and to develop a preliminary design for a research flight engine.

During the nine-month course of the contracts, each company will prepare engine development plans for the second phase of the program. These plans will be considered as technical proposals for further work on the project.

Because the hypersonic ramjet is intended ultimately to include flight research with the engine mounted on the *X-15 No. 2* rocketplane, the contractors will use as guidelines for preliminary design a weight limitation of 800 lbs. and dimensions compatible with mounting the engine underneath the aft fuselage of the *X-15*.

Schriever on Project Forecast

Based on requirements of the United States concept of controlled military response to any attack or threat, Air Force Project Forecast recommendations emphasize better target accuracy for nuclear weapons.

This and other conclusions in the project Forecast study were made public for the first time in an article written by Air Force Systems Command Chief Gen. Bernard Schriever for the April-May issue of *Air University Review*.

Other items judged of first military concern in the study conducted by the Air Force R&D branch included a recognition of the need for a number of new systems to counter enemy threats: anti-missile systems, military space systems, and a deterrent to submarine-launched weapons.

Some of the conclusions spelled out in the Schriever article are included in the following statements:

—"Our current intercontinental ballistic missiles are not well enough suited to extracting military targets and limiting collateral damage to the surrounding area." New systems must stress precisely controlled delivery.

—"Our delivery systems will require standoff strike capability to survive in both general and limited war applications."

—"Low-yield clean nuclear weapons and improved non-nuclear weapons with very accurate all-weather and night delivery capability are essential."

Schriever stressed the need for high performance general (less than nuclear) military weapons systems "with extreme versatility and multiple usage throughout a wide scale of conflict intensity where ballistic missiles would not be usable."

Schriever mentioned that several new systems concepts offer possible help in countering the threat of sea-launched missiles but did not identify them. One need considered seriously by members of the Forecast effort is for the nation to develop "ability to cope with the problem of potentially hostile space satellites."

Adobe Motor Tests Due

Thiokol's Adobe motor with beryllium additives is scheduled to begin its testing program in June and complete at least a dozen trials by December

Thiokol Corp. has a $800,000 contract from the Air Force Rocket Propulsion Laboratory, Edwards AFB, Calif., and Beryllium Corp.'s Nuclear Division, Hazelton, Pa., was awarded a $400,000 subcontract Mar. 25 for the beryllium to be added to the liquid rubber polymer.

Application of the Adobe is to be in an upper stage with specific impulse "substantially above that of existing motors."

Helium-Oxygen Test Ended

The Air Force has ended its second 30-day evaluation of a helium-oxygen atmosphere at 7.34 psi at the School of Aerospace Medicine.

The Air Force is studying the mixture for possible future space cabin work, because it does not produce decompression sickness in astronauts upon depressurization and it is less hazardous in terms of possible spacecraft fires. Although some speech differences are noted, Air Force doctors said that communications were maintained easily.

McNamara on Nuclear Race

There is no indication that the Soviet Union is actively in a race to match United States strategic nuclear forces at this time, Secretary of Defense Robert S. McNamara says in an interview appearing in the April 12 issue of *U.S. News and World Report.*

"I'm simply saying that there is no indication they are in a race at this time," McNamara said. "They do have the capability to catch up by 1970. Therefore, I cannot give you a final estimate what their 1970 force will be. . . . Their rate of expansion today is not such as to allow them even to equal, much less exceed our own 1970 force."

McNamara estimates the U.S. has a superiority over Russia on the order of three or four to one and added that, qualitatively, the difference is even greater. "They have no solid-propellant strategic ballistic missiles, for example," he said. Like the U.S., the Soviets are working toward development of an antimissile missile but "there's no reason to believe they're ahead of us," McNamara said.

Noting that by June 30 this year the U.S. will have 416 *Polaris* missiles deployed, McNamara said the Soviets will have "substantially fewer missiles deployed in submarines" and that most of their vessels are diesel-powered while all *Polaris* submarines are nuclear-powered, with the 60% deployed on station "virtually invulnerable."

The Defense secretary said he assumes the Russians are developing solid-fuel missiles but do not yet have them. He added that their boasted 60- and 100-megaton warheads for liquid-fueled missiles are not as desirable as smaller yield U.S. devices because "it's quite clear to us that 30 warheads of one megaton each offer far more offensive power than does one 30-megaton warhead."

AFSC Will Replace EDP

Replacement of electronic data processing equipment in support of R&D data systems at four major Air Force Systems Command installations is planned by the Air Force.

Industry will receive RFPs to replace present equipment in use by Systems Engineering Group, Wright-Patterson AFB, Ohio; Ballistic Systems Div., Norton AFB, Calif.; Air Force Flight Test Center, Edwards AFB, Calif.; and Air Proving Ground Center, Eglin AFB, Fla.

Getting the idea across.

We're really not going to try to make some kind of case here that communications between the male and female can be improved. That would be like chewing on razor blades. We will leave understanding between the man and the woman to brasher, broader, braver and possibly even bawdier minds than our own. What we're talking about really is communication between various scientific disciplines. Can a chess player really talk to a golfer? Can an electro-mechanical engineer really talk to a physicist? Can a boy of 22 find happiness with a woman of 50? It's a big problem. At Hydro-Aire (you had to know we'd get around to talking about ourselves eventually), we're loaded with hydraulic engineers, electronic engineers, electro-mechanical engineers, pneumatic engineers, mechanical engineers and several types we haven't even been able to classify as yet. We know they talk to one another. "Have you checked out that new waitress over at the lunchroom?" "No." "What's wrong, you sick or something?" "No. I brown bag it." So, at least, we know that we're going in the right direction. They talk to one another. Whether they're communicating or not is another problem. The best way to prove the pudding, we suppose, is to look at what Hydro-Aire has accomplished. There are brake control systems which rely on electronics, servomechanisms, electro-mechanics and hydraulics. There are liquid coolant pump assemblies which require electronics, electro-mechanics and hydraulics. There are flight control systems which require electronics, hydraulics, electro-mechanics and pneumatics. And a lot of other things, too. Now, you just couldn't do all of this if nobody was communicating. There's a statement in a brochure entitled "Hydro-Aire—Systems Capabilities" which is a little overbearing, even if true. "Hydro-Aire began to build up the compatible existence of a broad range of engineering disciplines 'under one roof'; backed up by a type of management attitude that understands the delicate problem of utilizing the talents of technical specialists and blending them for optimum efficiency." Phew! What that really means is that Hydro-Aire has a bunch of talented guys around who jell their thinking and are able to put it into words. We have a number of those brochures around. Please send for one. The pictures are excellent.

HYDRO-AIRE DIVISION OF CRANE
3000 Winona Avenue, Burbank, California

Circle No. 4 on Subscriber Service Card

Early Bird Operation May Be Speeded

Comsat Corp. officials report that highly successful orbiting saved five days of drift time; second satellite may go this year

by Suzanne Montgomery

THE OPERATIONAL PROGRAM of the *Early Bird* communications satellite may be accelerated by several days due to its highly successful launch from Cape Kennedy April 6, officials of Communications Satellite Corp. have indicated.

Comsat last week announced new plans to kick the synchronous satellite, built by Hughes Aircraft Co., into a stationary orbit at approximately 8:30 a.m. EST, April 9. Firing the kick motor on the sixth apogee was to take it out of transfer orbit and place it in essentially the desired position for communications between Europe and North America. Dr. Siegfried H. Reiger, Comsat technical vice president, said *Early Bird's* excellent orbital parameters permitted switching this maneuver from the planned fourth apogee to the sixth apogee, thus eliminating approximately five days of drift time.

Approximately 12 hours after the launch aboard a *Thrust-Augmented Delta,* the ground station at Andover, Maine, reported the satellite had an apogee of 22,680 statute mi., perigee of 900 statute mi. and period of 11 hours, 10 minutes.

At this point—second apogee—Andover scientists conducted a brief check of the system's television capabilities with a standard TV window pattern. Transmission was "excellent," Reiger said. As of late last week, all maneuvers and tests of *Early Bird* were "definitely successful."

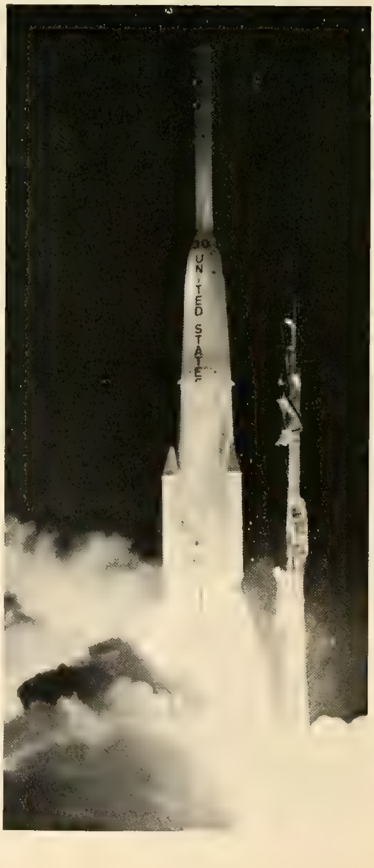
The second *Early Bird,* now assembled at Hughes, could be launched later this year, depending on the performance and utilization of the first satellite. Joseph V. Charyk, Comsat president, said a back-up satellite could be provided for Europe and the U.S. if the demand is great enough. He pointed out that at present satellite communications are limited more by lack of ground stations than by satellite capabilities. He cited Hawaii and South America as areas where demand is present but ground stations are not.

- **Smooth launch**—The *Early Bird* launch marked the 27th success in 30 attempts for the Douglas *Delta* vehicle. It was also the second success in as many tries with the *Thrust-Augmented Delta.* The first one lifted *Syncom III* on Aug. 19, 1964.

Liftoff occurred at 6:47:49 p.m. EST, shortly after the only hold that interrupted the countdown. The hold came at T minus 15 minutes and pushed the launch past the 6:30 opening of the one-hour window.

Robert H. Gray, director of *Early Bird* launch operations for Goddard Space Flight Center, said the hold was caused by abnormally low pressure in a second-stage helium sphere. Launch officials decided to switch to a backup system and manually boosted pressure in the sphere from 300 psi to the required 1,700 psi.

EARLY BIRD leaves Cape atop Delta.



The launch was described by both NASA and Comsat officials at Cape Kennedy as very smooth during all phases. Casings of the three solid strap-on motors could be seen floating down for several seconds after they were jettisoned at about T plus 1:50.

Second-stage ignition was confirmed at T plus 2:32. Second-stage cut-off occurred at about T plus 5:14. The second stage remained coasting with the spacecraft and third stage for 21.5 minutes after second-stage cutoff.

Rockets were then fired to spin-stabilize the third stage and spacecraft just before second-stage apogee. The second stage was separated and further signals confirmed third-stage ignition, burnout and finally separation of spacecraft and injection of *Early Bird* into its transfer orbit at T plus 28:40.

At this time, mission control was transferred from Cape Kennedy to Comsat's Control Center in Washington.

As expected, spacecraft telemetry was lost at the Cape about 620 seconds after liftoff, but telemetry signals from Antigua and Ascension Islands and Johannesburg, South Africa, were described as "very good" by Martin Vottaw, Comsat's *Early Bird* project manager at the Cape.

- **FCC watches**—Witnessing the launch were all six members of the Federal Communications Commission, watchdog for the privately operated venture.

In Washington, Vice President Hubert H. Humphrey visited Comsat headquarters, where corporation officials, their families and members of the press observed the launch on closed-circuit television. Humphrey, chairman of the National Aeronautics and Space Council, called *Early Bird* "our message to the world, emphasizing cooperation as a means to developing opportunities."

On Wall Street, Comsat closed at 61⅜ one day after launch. It had climbed six points in the week following announcement of the launch date. ■

'Ready to go operational' . . .

SNAP 10A Test Exceeds Expectations

First nuclear power source to be tested in space produced 630 watts peak; expected to stabilize at 585 watts, 28 volts

VANDENBERG AFB, CALIF.—SNAP 10A, first nuclear power system to be tested in space, was reported functioning perfectly last week after reaching full-power operation following launch into polar orbit April 3 aboard an *Agena* spacecraft.

Test of the 970-lb. system, developed by Atomics International Div. of North American Aviation, Inc., under funding by the Atomic Energy Commission, will provide the basic input to knowledge of the lifetime of such a system in space.

The *Agena* spacecraft, carrying an ion engine developed for the Air Force by Electro-Optical Systems, Inc., as a secondary experiment (see p. 10; also M/R, April 5, p. 22), was launched by an *Atlas* into an accurate orbit with apogee of 717.7 n. mi., perigee of 699.5 n. mi., period of 111.5 minutes, and inclination of 90.2 degrees.

The spacecraft was expected to remain in orbit at least 3,500 years.

Shortly after full-power operation was attained April 4, operating figures were 630 watts output from the electrical system at 30.7 volts.

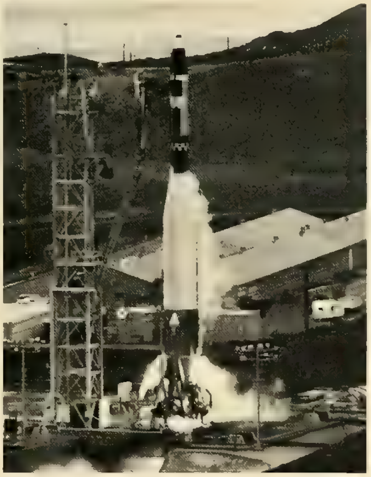
Following stabilization, output was expected to be 585 watts, in a static control mode and operating without further adjustment. Nominal voltage output was expected to be 28 volts and nominal current 17.8 amps.

Total system efficiency appeared to be somewhat better than anticipated.

Fundamental aims of the test were to demonstrate capability to survive launch and ascent, to attain safe orbit for nuclear operation, to initiate reactor start-up remotely and to monitor system performance, to stabilize at rated power, to check the adequacy of nuclear safety provisions, and to establish the 90-day operational capability of the SNAP-*Agena* orbital system.

The test also was to determine space effects on thermal/control coatings nuclear radiation shield effectiveness, thermal capability, and effects of high-temperature vacuum operation.

● **Silent service**—Atomics International estimated that the power unit had a good chance of operating for at least a year. One year was the design point. However, the goal of this first flight test is only 90 days. Useful operation of the system is restricted by the lifetime of the *Agena* spacecraft's telemetry system, which is of standard design so far as radiation hardness is concerned.



SNAP 10A launch aboard Atlas-Agena

On failure of the telemetry system, or prior failure of any components which would prevent further purpose of the test, SNAP 10A will be shut down automatically by ground command.

Nevertheless, the test is expected to provide data on lifetime of such a system in space. Atomics International believes the system could be made to operate for three to five years without encountering any basic problems such as uranium burn-up, fuel-element failures or any other mechanical restraints.

"The question really is the lifetime of the spacecraft itself, whether it is made to fully utilize the power that long," an AI spokesman said.

AI reached full-power operation with a complete duplicate of the flight unit, the final ground test system, Jan. 22 in a vacuum tank. That system has since operated "hands off" continuously as expected but has not yet run long enough to provide useful long-term data.

● **Shielding**—The test is expected to provide space shielding information that was not hitherto available and will be useful to future space system design. SNAP 10A is equipped with a 225-lb. shadow shield of a shape that attenuates radiation to the rest of the satellite vehicle. Radiation sensors so far are operating as expected.

In ground tests, the presence of atmosphere and apparatus distorts the radiation measurements, whereas in-space measurements should be free of scattering effect. Data collected from the experiment will provide information on shadow shielding design and material with regard to electronic payload or crew. Material used is lithium hydride.

The flight system now in orbit shields the *Agena* electronics to levels below those which would degrade the performance of selected components (2 x 10^{12} nvt/year, 10^7 rads/year), but which are too high for some components.

An operational SNAP 10A system would require another 50 lbs. of shielding.

Reactor portion of the 970-lb. systems weighs 250 lbs. The rest is power conversion system, shield, 75 lbs. of special diagnostic instrumentation and other equipment.

Although the *Agena* is stabilized in a tail-down position, no attitude-control system is required for operation of the SNAP 10A, since there is no orientation requirement. It would operate tumbling or spinning.

● **"Ready to go"**—At the heart of the reactor is the core vessel, a steel tank 9 in. in diameter and 15.5 in. high. Each element consists of a rod of fuel-moderator material, a homogeneous mixture of zirconium hydride—the moderator—and uranium 235—the fuel. The fuel accounts for 10% of the weight of the mixture.

Packed vertically into the core vessel are 37 cylindrical fuel-moderator elements. Fuel-moderator rod is clad with Hastelloy. Reactor coolant is a liquid alloy of sodium and potassium metals. Pump rate is about 13 gpm.

AEC and AI sources declare SNAP 10A could be qualified as an operational power source. "We are ready to go," a source said. ■

To replace Atlas-Agena . . .

Uprated Atlas Confidence Vote Likely

Affirmative decision would extend booster's use through decade; R&D cost would be $15 million; mission would not overlap that of Titan III-X

by Hal Taylor

A FAVORABLE REPORT on the uprated *Atlas SLV 3X* booster by the launch vehicle panel of the joint NASA/DOD Aeronautics and Astronautics Coordinating Board is expected in about two weeks.

If approval is received, the *Atlas* will remain in the U.S. booster stable for the rest of this decade and probably into the 1970's.

NASA officials are pushing hard for approval of the launch vehicle, and informed sources report that the Air Force also favors the programs.

The launch vehicle panel is headed by Milt Rosen, senior scientist in NASA's Office of Defense Affairs, and Dr. Alexander Flax, assistant secretary of the Air Force.

The AACB is headed by Dr. Harold Brown, assistant secretary of defense for DDR&E, and Dr. Robert C. Seamans, Jr., associate NASA administrator. The latter officials will make the final decision on the program.

It is estimated that research and development for the uprating will cost about $15 million and will take about 18 months.

NASA's plans call for using the booster to replace all of its planned *Atlas-Agena* missions beginning approximately in 1968. It might be used for all *Atlas-Centaur* missions, but there will be only a few of those flights scheduled in that period.

● **25,000 lbs. more thrust**—The major portion of the uprating will be achieved by boosting thrust of the *Atlas*'s two first-stage engines from 165,000 lbs. to 175,000 lbs. each. The sustainer engine thrust will be increased also—from approximately 55,000 to nearly 60,000 lbs.

In the first stage this is achieved by changing the fuel injection method to provide more holes in the pattern. This enables the engines to use the oxidizer more efficiently and provides an approximate 3-second increase in specific impulse. Increasing the sustainer engine to 65,000 lbs. will require only a small amount of improvement, according to industry sources, because it now is reaching 60,000 lbs. in some tests.

NASA favors uprating the booster because it would provide an increase of almost 30% in booster capability. They are also impressed with the *Atlas*'s reliability record of one failure out of more than 20 NASA launches.

The *Atlas SLV 3X* launch vehicle competes to a certain extent with the recently approved Air Force *Titan III-X*. NASA's position is that the two launch vehicles are designed for different types of missions; that a new *Titan III-X* launch pad would have to be built at Cape Kennedy; that *Titan III-X*'s reliability still has not been proved; and that the new Air Force booster will be far more expensive than *Atlas*.

The *Atlas* is built by General Dynamics/Astronautics and *Titan III-X* is being developed by Martin Co. ■

GT-6 Calls for Third-Orbit Rendezvous

The *Gemini/Titan II-6* crew of Walter M. Schirra and Thomas P. Stafford will attempt the first U.S. space rendezvous as their spacecraft begins its third orbit over Hawaii.

The flight plan for the mission—slated for late this year—was revealed by Manned Spacecraft Center's *Gemini* Director Charles Mathews.

He said the *Gemini-Titan II* and the *Atlas-Agena* will be brought to "operational readiness" through a simultaneous countdown. Just prior to launch of the *Agena* a hold will be placed on the *Gemini* countdown and the *Agena* will be sent into a 161-n. mi. circular orbit. The *Gemini* will be launched 90 minutes later as the *Agena* is completing its first orbit. The spacecraft will be inserted into a nominal 87-141 n. mi. elliptical orbit. The *Titan II* has variable azimuth of from 82 to 105 degrees and the attempt will be made to align the spacecraft with the plane of the *Agena* inclined at approximately 28.87 degrees during the first spacecraft orbit. At the beginning of the second orbit, the command pilot may perform a translation burn using the orbit attitude and maneuvering system (OAMS) to adjust the altitude of the spacecraft apogee to approximately 15-20 n. mi. below the *Agena*.

Before the spacecraft arrives at the adjusted apogee, the command pilot will make another translation at the nodal crossing to shift the spacecraft into the plane of the *Agena*.

The spacecraft radar will "lock on" the target shortly after the spacecraft passes through the perigee at the beginning of the third orbit. This will give the *Gemini* crew about two hours to track the *Agena*. Range and range rate with azimuth and elevation referenced to the spacecraft axes will be collected continuously by the radar for the onboard computer. This will be displayed as velocity and attitude values for thrusting and correcting maneuvers in the terminal phase of rendezvous. The pilot will circularize the spacecraft orbit at the following apogee, midway through the third orbit.

The two vehicles will be orbiting in concentric formation, the *Gemini* approximately 15-20 n. mi. below the *Agena*. At about 130 degrees back from the point where both vehicles will be in position for docking, the terminal phase or the move in on the target will be started. The pilot will put the OAMS in posigrade to move the spacecraft up into the *Agena*'s *orbit*. Mathews said the docking maneuvers will begin in the vicinity of the Hawaiian Islands in daytime. After docking, the pilots may back away from the target vehicle and redock several times before abandoning the *Agena* in space, he said.

Senate Okays $15.28 Billion for DOD

Total approved is only $13 million below Administration request; MOL would get full $150 million sought for it

THE SENATE passed by unanimous vote the Fiscal Year 1966 Dept. of Defense authorization bill, including the full $150 million requested for the Air Force's *Manned Orbiting Laboratory*.

Total funds approved were $15,283,800,000. This included $8.687 billion for procurement of aircraft, missiles and naval vessels, and $6.596 billion for research, development, test and evaluation. The total was only $13 million below the Administration's request, and some $500 million above that voted by the House Armed Services Committee.

In discussing the *MOL* request, Sen. John Stennis (D-Miss.), who is acting chairman of the Armed Services Committee in the absence of ailing Richard B. Russell (D-Ga.), said that "the committee was informed that these funds will not be obligated until the Department is sure that a sound approach is being made and that the results that can be expected from the program are worth the cost."

There have been reports that the House Armed Services Committee, in its vote, narrowly missed cutting out *MOL* funds on the basis that they would not be used this year. However, sources report that although the Air Force received a cut of $212.5 million in its RDT&E request at the hands of the House committee, it was not specifically applied to *MOL*. The full House has not yet acted upon the authorization bill.

- **Other areas**—The Air Force also received full funding for *Titan III*, *Gemini*, large solid booster, and space detection and tracking system (SPADATS) requests. Likewise fully funded in the Air Force astronautics category—which totals $995.1 million—were reentry and recovery projects.

The Army's astronautics request, totaling only $2 million, also was allowed. This money will be supplemented by $18.3 million still remaining from the FY 1963 *Advent* program, and will go towards work on ground environment of the DOD satellite communications program.

The Navy's $24-million request for application of space technology to the fields of communication, navigation and ocean surveillance was granted.

Complete funding for missile RDT&E—at $632.8 million for the Army, $381.3 million for the Navy and $757.6 million for the Air Force—was allowed, and procurement funds for missiles for the three services and the Marines were granted as requested.

Military sciences funds for all three services and the defense agencies were trimmed by 5%, making those amounts $160.8 million for Army; $190.5 million for the Navy, $160.5 million for the Air Force, and $483.4 million for the defense agencies. The committee said that it was making the 5% reduction "in the absence of clearer and more convincing indication that the results of this work are really productive of progress toward identifiable defense objectives." However, it pointed out that a total of $300 million is available to the Secretary of Defense from emergency and other funds if the need is urgent.

The committee added $82 million to the Air Force's request for aircraft for acceleration of development of an advanced manned strategic aircraft. This much had originally been cut from the Air Force's request to DOD. ■

House Group Urges Cuts in OAO, OGO and Surveyor

THE HOUSE Space Sciences and Applications subcommittee tentatively voted cuts in the *Orbiting Astronomical Observatory, Orbiting Geophysical Observatory,* and *Surveyor* programs in its consideration of NASA's Fiscal Year 1966 authorization request. Total cuts in the Space Sciences and Applications area are approximately $36.7 million.

The subcommittee, chaired by Rep. Joseph Karth (D-Minn.), will recommend to the full House Science and Astronautics Committee that a $6.2-million cut be made in the *OAO* to delete the fifth or last vehicle. It will ask that another $5.4 million be trimmed from *OGO* to eliminate the last planned spacecraft in that program.

A $4-million fund for a roving vehicle for the *Surveyor* spacecraft has been trimmed back to $2.5 million in subcommittee action, on the basis that such a vehicle should remain in the study phase until at least one *Surveyor* is launched successfully. A $1-million cut also was voted in the Block II *Lunar Orbiter* series.

- **Centaur setback**—A $10-million slash was made in sustaining engineering and maintenance for launch vehicle procurement for *Centaur*. Karth told M/R that he could not understand how the agency could request $19 million in such a fund for *Centaur*, when the vehicle is not yet operational. An additional $5 million was deleted from a general launch vehicle procurement fund, after NASA reportedly said in testimony that it planned to reprogram this money. Another $3 million was stricken from launch vehicle development supporting research and technology, to keep it in line with requests for previous years.

In the administrative operations category, a total of $4.6 million was deleted. A request for funds for automatic data-processing equipment rental at Goddard was trimmed by $4 million, and $600,000 was cut from maintenance costs on buildings.

The Manned Spaceflight and Advanced Research and Technology subcommittees have already agreed upon recommendations to present to the full committee (M/R, April 5, p. 13).

Teague reports . . .

Committee Asks LBJ for MOL Ruling

Space Committee fears breakup of Gemini contractor team; Second Canaveral Space Congress hears strong support for military space

by Lawrence J. Curran

COCOA BEACH, FLA.—The House Committee on Science and Astronautics has written to President Johnson to stress the need for a decision soon on the proposed Air Force *Manned Orbiting Laboratory* program.

Rep. Olin Teague (D-Tex.), second-ranking majority member of the space committee, told MISSILES AND ROCKETS that the letter urged the Administration "to take a careful look as soon as possible and make a decision" as to whether or not the *Gemini* spacecraft would be used in the *MOL* program.

Teague voiced his committee's support for a military man-in-space effort in a speech before the Second Space Congress of the Canaveral Council of Technical Societies, held here April 5-7.

He also said that the subcommittee on Manned Spaceflight, of which he is chairman, "almost unanimously" favors restoring some $30 million which it earlier trimmed from the *Apollo* program.

Teague had these additional comments in connection with the Space Agency's Fiscal Year 1966 budget request:

—He predicted a vote by the full committee, as recommended by the subcommittee, to restore funds deleted by the Bureau of the Budget in NASA's request for the big solid program, the M-1 engine and the SNAP 8.

—He felt that NASA Administrator James E. Webb should ask for a supplemental *Apollo* authorization to provide a cushion for unforeseen slippages in the timetable for a manned lunar landing by the end of the decade.

Although the Manned Spaceflight subcommittee originally voted a $90-million across-the-board cut in *Apollo* money, the success of the recent *Gemini/Titan-3* flight dulled the knife, said Teague, so that the reduction was held to $30 million.

He added that members of the Manned Spaceflight subcommittee then toured key NASA and industrial installations involved in the manned flight program and came away inclined to restore the $30 million.

Teague said he thought a motion to restore the money would have been made to the full House space committee late last week, but hesitated to guess how the move would be received. Neither would he set a figure for the supplemental authorization Webb might seek.

The space committee's letter to the President was prompted in part by a concern that the valuable *Gemini* industrial team headed by prime contractor McDonnell Aircraft Corp. might be disbanded if a decision on *MOL* doesn't come soon. Teague said the remainder of the two-man capsules procured by NASA were well into production at McDonnell.

• **More MOL backing**—Teague's remarks in support of *MOL* closely paralleled those of Maj. Gen. Don R. Ostrander, commander of the Air Force Office of Aerospace Research, at the three-day session here.

Ostrander said that in every environment in which man has learned to live there have emerged "valid military missions which man himself can best perform. I believe that the *MOL* will enable us to come up with some of the answers" to the question of what man can do in space to contribute to the military mission.

NAA Studies Astronaut Monitoring Sans Sensors

NASA's Electronics Research Center, Cambridge, Mass., has awarded a $50,000 contract to North American Aviation's Space and Information Systems Div. for a 12-month study to develop a technique for monitoring of astronauts without attached sensors.

Medical systems and devices under study include a temperature detector that would sense skin changes without touching the skin, infrared thermometers to detect change of body temperature from a distance, and a measuring device that compares input and output of air into a space suit.

Dr. George E. Mueller, NASA associate administrator for manned spaceflight, also touched on the merits of the *MOL* concept in both his keynote address at the Space Congress and informal remarks after the speech, which was entitled "The National Space Program."

He said he thought a current joint NASA/Air Force study would point to the need for both the space agency's *Apollo Extension System (AES)* and the *Gemini-B/MOL*.

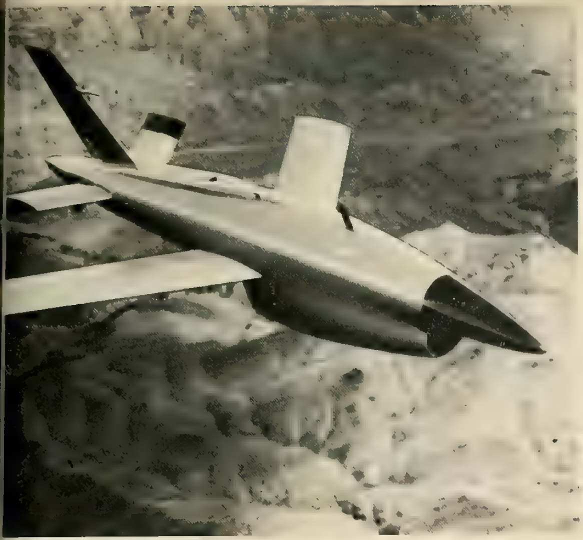
Regarding the space agency's FY '66 authorization, Mueller said he "hoped Rep. Teague is right" in predicting that the bill would reach a vote in the House before the Easter recess. He said he thought it was premature to discuss a supplemental request until the full Congress has voted on the money bill. He emphasized, however, that the FY '66 funding level probably would establish the trend for the space agency for the next several years.

E. Z. Gray, also of NASA's Office of Manned Space Flight, told M/R he thought the future of the *MOL* program hinges on how persuasive an argument the Dept. of Defense can offer the Administration in justifying it.

He expressed the opinion that NASA's plans for an *Apollo Extension* system should not necessarily rule out *MOL* development because there is enough difference in the missions of the two to warrant pursuit of both.

• **Well-attended**—Gray's talk on NASA's future programs at the Congress probably was the best-attended of any of the technical sessions. In it, he stressed that one of the cardinal rules guiding the space agency's plans was that it must make maximum use of hardware either already developed or currently in development.

More than 800 registered for the Space Congress, during which some 45 technical papers were presented. A score of industrial exhibitors also participated. ■



ARTIST'S DRAWING of Ryan Firebee target drone.

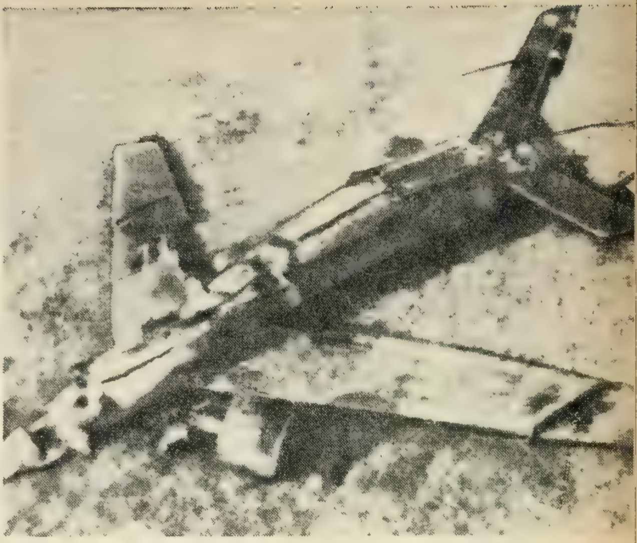


PHOTO OF DOWNED aircraft released by Red China.

Red China claims 2 in 3 days . . .

Plane in Photos Looks Like Firebee

by Donald L. Zylstra

PHOTOGRAPHS of a downed "pilotless American reconnaissance airplane" put on display in Peking leave little doubt that it is a U.S.-built *Firebee* drone manufactured by the Ryan Aeronautical Co. in San Diego, Calif. The Chinese reported that it had been on display since April 2, but did not further identify the aircraft, which carried no markings in the picture released.

Comparisons with target drones used by U.S. armed forces indicate that the aircraft most closely resembles the *Firebee* (BMQ-34A), currently operational in the Army, Navy and Air Force. This improved *Firebee* is listed as having a service ceiling of 60,000 ft. and an endurance capacity of "75 to 96 min. at 50,000 ft." with a speed of 625 mph. Maximum range for the aircraft would thus be more than 600 mi.

However, in usual service operation the drone rarely travels more than 200 to 250 mi. Defense sources refused to indicate whether the drones have been employed in areas from which a flight into Red China would be possible. But, at maximum range, such a flight would be possible from Japan or South Viet Nam. Only an intermediate-range flight would be required to reach portions of Red China from the Philippines or Thailand, and a flight from Nationalist Chinese bases in Formosa would be well within normal operational ranges.

The official New China News Agency report claimed two such aircraft were brought down in three days, the second having been shot down in south central China April 3. The agency also claimed that the second pilotless plane recovered in south China was the fifth "enemy" plane downed in three months, and asserted it carried a plate identifying it as manufactured in San Diego.

- **Somebody else**—Representatives of each of the three armed forces denied any knowledge of its use by their own service. An Army spokesman noted that Army launches its version of the *Firebee* from ground sites only. Since the drone can also be launched from aircraft such as the B-26 and from shipboard, many knowledgeable military people suggest that one of these two modes would "be the logical method" if the U.S. wanted to send a *Firebee* over a precise location in China, unless launching from Formosa is considered.

Other sources noted that launches by Nationalist China or one of the U.S. armed services aren't necessarily the only alternatives for explaining the drone's presence in Red China. Several U.S. firms producing drones for the Government feature a special launch-anywhere service, accomplishing overflight of areas in most parts of the world with technical personnel, equipment and launch crews furnished by the contractors themselves. "Thus it isn't unreasonable to assume that a special *Firebee* launch could be arranged by some agency of government other than the military—CIA, for instance," one M/R source speculated.

Military people cited several instances where substantial information about a country's defenses could be acquired, "merely by sending in *Firebee* probes, even without cameras or other surveillance equipment." For instance, *Firebee* with its internal radar image augmentation equipment can simulate the radar image of aircraft many times its size. Thus, if it were commanded to over-fly defense installations, much would be learned about the quality of detection equipment, airborne or ground defenses and, alertness of crews, merely by noting reaction time and accuracy, observing from a distance on radar.

The drone shown in the Red Chinese photo has nose, wing, fuselage and empennage configuration which identify it as the *Firebee*. The long nose, vertical tail fin and characteristic sweep of the wings are identical, as is the pitot tube on the vertical fin. ■

BUGATTI
W.T. VINSON

Merton-Smith and the 1926 Targa Florio

Dr. Burton Merton-Smith seemed as though he were covered with heavy grease from head to foot. He was in his garage, his nose just inches away from the engine block of a car which, because of its famous fluted horseshoe radiator, I knew was a Bugatti.

"Where on earth did you get this?" I queried.

He jumped, not having heard me enter the garage. "Don't you knock before you enter garages," he laughed. "Now, don't berate me for a little esoteric indulgence. Wife Carol has been after me for weeks. Something about not even having an automatic dishwasher. Isn't she a beauty?"

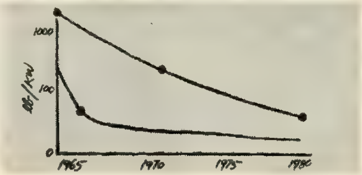
I knew, of course, he was referring to the car, although the appellation could have easily referred to Carol as well. "What type is it," I asked.

"I see you're up on these things, too," Merton-Smith said. "She's a Type 35B, 2.3 litre. Took one, two, three at Targa Florio in 1926, so she's commonly known as the Targa Model. And she really moves. When I get these valves fixed up, there are 16 of them, and get the engine back together, I'll be able to do 130 mph on the straight."

"Don't you ever get tired of engines," I laughed, alluding to Merton-Smith's current involvement at Electro-Optical Systems on electric propulsion.

"Well," he answered, "you'd be amazed at the specific impulse the 35 delivers."

"That's the first time," I said, "that I've heard of an automobile's power efficiency expressed in terms of specific impulse. How much do you think this one has?"



"I'd say about 10,000 seconds. I could figure it out if you'd like, but that was not what Ettore Bugatti really had in mind. There was an artist for you. A real thinker. He revolutionized the concepts of motor car racing. Little engines, high revs, fantastic handling and honest efficiency. That's the same advanced, state-of-the-art approach EOS is taking in electrical propulsion.

"Interplanetary travel, for instance, is a lot like a long, hard grueling race. The engine takes a hell of a beating and it's got to stand up. In my opinion, and it's one shared by some fairly respectable thinkers, whenever longtime, continuous or repeated use of an engine in outer space is required, nothing can beat electric propulsion."

Carol came through the door carrying a tray with two ice cold glasses of cider. She looked radiant in a beautiful, low-cut yellow summer frock. She swished when she walked and she smelled of Spring and I hated Merton-Smith for having found her first. They had been married for over 20 years (there had been some romantic story about Spain and a bullfighter who had been crazy about her, but I had never been able to get the details) and, in the 15 years I have known them, she has always been the most attractive woman in any room.

"Thank you, darling," Merton-Smith said, "now would you mind toddling along. We're talking business." She left, smiling. "The problem up there, of course, is getting the power. Up to now, we've been thinking almost entirely in terms of nuclear reactors as the power source and, up to now, it's made all kinds of sense. We've put three cesium ion engines into a battery-powered ballistic flight for the Air Force to prepare for coupling with a nuclear reactor for a 90-day orbital flight."

"The nuclear reactor is really the answer, I suppose," I said, leaning against the shining car. Merton-Smith frowned at me and I quickly moved away and took a seat on an old wooden crate.

"Not yet. It will be about a decade before we'll be able to get a real efficient one up there. The problem is what do we do from now until then. EOS has the answer, though. What's the greatest nuclear reactor in the universe?"

"The sun, naturally," I answered.

"So there it is," he said, waving his big greasy hand at the sky, "and all we have to do is use it. Using that same beautiful Bugatti thinking, we've come up with the answer. We can convert solar energy now, of course, but the big problem is weight in relation to power output. In the case of electric propulsion, we're talking in kilowatt levels."

He stopped for a moment, dipped his finger in a large can of grease and began drawing on the garage floor.

"On this side we're talking about pounds/kilowatts and down here years. Right now, the nuclear reactor system is way up here. About 1300 pounds per kilowatt. Now look at the curve as the system gets down to twenty to forty pound level which is required for efficient propulsion. We're way over in '76 or '77.

"If we look at the solar energy conversion system, we're at the 130 pound per kilowatt level right now but in just a year or two we can get down to the propulsive level. The solar energy curve looks like this."

I whistled. "What you're really saying, then, is that interplanetary travel is possible right now, or, at least, in a year or two."

"Exactly," Merton-Smith smiled. "And the beautiful thing is, it can be done with present equipment. We just set our payload into orbit, erect the solar panels and take off."

"That means with the EOS cesium ion engine and the EOS lightweight solar power system we'll be able to make interplanetary trips much faster, doesn't it?" I asked.

"Yes and no," Merton-Smith said. "What you're really talking about is the feasibility of larger payloads. To the nearer planets, the flight time might be the same, but the package you deliver can be much, much larger."

"And you're sitting here fiddling around with a 1926 Bugatti," I laughed.

"Relaxation, my friend, is required of every scientist," he answered. "And besides, that cesium ion engine has a terribly undistinctive radiator."

Dr. Burton Merton-Smith will be happy to exchange resumes with you. You send yours to him. He'll send his to you. Fields of interest: energy conversion, space propulsion, space probes, laser technology, imaging devices, optical systems and instruments, and information handling. EOS is an equal opportunity employer.

E
S

ELECTRO-OPTICAL SYSTEMS, INC. 302 North Halstead Street, Pasadena, California
a subsidiary of Xerox Corporation

Circle No. 5 on Subscriber Service Card

Technical Countdown

OPTICS

ALOTS Successfully Ground Tested

The first operational test demonstration of the automatic tracking sensor portion of the airborne lightweight optical tracking system (ALOTS), now under development for the Air Force Eastern Test Range by the Nortronics division of Northrop Corp., was successfully made during the recent launch of *Gemini 3*. The ground-based vidicon tracker proved it could ignore the *Titan II*'s fiery plume and lock firmly on the nose until the space vehicle was well beyond human sight. The gimballed tracker was manually locked onto the nose of the *Gemini* prior to launch and then switched to automatic tracking. The nose is tracked because it represents the highest point away from the plume, a source of instability for photo records previously obtained by ground-based IR trackers. ALOTS continued to track automatically and to hold the missile tightly within the center of the TV monitor through the launch phase until the *Gemini* vehicle was well out of visual range.

Bimat Film Used for Ranger IX Photos

The benefits of Eastman Kodak's Bimat film process were effectively demonstrated by production of high resolution photographs directly from a cathode ray tube during *Ranger IX's* recent lunar TV transmissions. The film used was 35 mm Recordak Dacomatic, exposed by Jet Propulsion Laboratory engineers at Pasadena, Calif. The film negative was then combined with Bimat self-processing film in a 35-lb. prototype processor developed by Mark Systems, Inc. The result was a negative and a positive film strip produced in less than 15 minutes. (The positive could have been pulled off, at the expense of negative loss, in less than one minute, said Kodak officials.)

ELECTRONICS

PRADOR Molecularized

As a practical demonstration of the advantages to be obtained from semi-conductor integrated circuits, Westinghouse Electric has rebuilt its highly advanced solid-state PRADOR (PRF Ranging Doppler Radar) system using molecular-electronic-circuit design. The result: a 50:1 size reduction, a 6:1 weight reduction and at least equivalent performance. Input power is slightly lower with the new engineering prototype, called Molecular PRADOR, and output power is about the same. The PRADOR transponder, developed in 1963, is a coherent interrupted CW radar system. The earlier transistorized prototype operates in the X-band with a peak output of 125 mw and has an effective operating range (with its interrogator) of 500 n. mi., performing range, velocity and angle tracking. Range accuracy, Westinghouse claims, is to within ± 0.5%, or three feet, and velocity to ± 1%, or 1 fps—whichever is the greater in either case.

Automatic Sun Acquisition for Surveyor

Because NASA's Deep Space Instrumentation Facility (DSIF) may take up to 60 minutes to acquire *Surveyor* at the beginning of its flight to the Moon, a new solar sensor will be put on the spacecraft to enable it to acquire the Sun automatically. Previously, the plan was for Sun acquisition to be carried out under command from DSIF. But delay in Sun acquisition for periods of 60 minutes cannot be tolerated if spacecraft temperatures are to be held within limits.

STINGS Proposed for MOLAB

A stellar-inertial guidance system would be the best approach for use in MOLAB (Mobile Lunar Laboratory), said General Precision Inc.'s Mitchell Streicher at last week's Second Space Congress at Cocoa Beach, Fla. His arguments: (1) MOLAB will be lunar landed (in the mid-'70's) unmanned and thus its navigation system must be capable of self-check and reliable self-alignment; (2) stellar-inertial techniques would assure that after occupancy by lunar explorers, the vehicle not only would not become lost, but could accurately locate and record landmarks for later study by providing continuous position-data readout.

MATERIALS

Lightweight H_2 Generator Developed

Hydrogen for fuel cell use is being generated simply and efficiently from a hydrocarbon fuel and water with a 90-lb. unit developed by Engelhard Industries, Inc. The generator, being developed by the firm under an Army Electronics Command contract, can be readily reduced to a 35-lb. field conversion unit, according to the Army. The kerosene-like fuel, called BTX-UDEX raffinate, costs about 25 cents per gallon commercially and is easily transportable. The H_2 production rate of 10 std. cu. ft. per hr. is capable of supplying sufficient fuel for a 500-watt fuel cell power system. Next step, said the Army, is to develop a portable generator/fuel cell battery system weighing no more than 70 lbs.

Machinable Carbide Offers Improved Gyro

A steel-bonded carbide, called Ferro-Tic C by its developers, Chromalloy Corp.'s Sintercast Div., reportedly varies less than two microinches in any direction in a year. In addition to its high stability, the material resists galling and it offers a very low coefficient of friction. The machinable carbide is believed nearly ideal for use as a gas-bearing material in gyroscopes. Raw stock, received in the annealed state, can be machined to rough accuracy (a few thousandths of an inch), then hardened, tempered and stabilized. With a final hardness of R_c69, rotating gyro components such as rotors and shafts can be hand-lapped to final size with diamond compounds.

BIOSCIENCES

Martian Life-Support Environment Studied

Experiments by scientists at Union Carbide's Research Institute with a variety of higher plant life and lower animal forms in an environment believed to simulate Martian conditions have shown many species to have an amazing survival capability. Dr. Sanford M. Seigel of the Institute reports that if life as complex as seed plants, indigenous to an Earth environment, can survive in the Martian environment, then simpler forms of life on the planet may have even better chances. Seigel believes that if life ever were to exist on Mars (for which there is some evidence), it is likely to be there now, existing in a form shaped by the environment. For example, Seigel has found that the combination of low oxygen and freezing temperatures, a condition found on Mars, permits survival among plants and animals which could tolerate neither condition alone. Also, some simple molds of fungi can reproduce under conditions more devoid of water and oxygen than Mars itself.

Rangers Confirm Moon Landing Areas

Wealth of new data obtained on craters, surface pattern; Surveyors must resolve arguments; second in two-part report

by Willard E. Wilks

THE SUCCESSFUL *Ranger* flights achieved the main objective of the program in determining that the Moon has areas smooth enough for manned landings, according to members of the photo-evaluation team.

They agree that a great deal of hard information beyond mere surface smoothness also was obtained. This includes things that can be readily seen and measured, such as size and shape of craters and differences in their distribution, slope of the lunar surface, and existence of identifiable features which seem to follow a pattern.

The photographs have not, on examination to date at least, changed any of the basic theories about the Moon or provided answers to such questions as depth of surface material and its composition—nor could they necessarily be expected to. It is possible, however, that some new light may be shed as *Ranger VIII* and *IX* photos are subjected to close study in coming months.

On the question of depth of surface layer, two things noted in the photos could support opposite points of view. One is the visibility of the grid pattern in such fine detail, if this detail is indeed the case. Some investigators think this is a good indication that the depth of the surface layer is only one or two feet.

- **Crater erosion**—On the other hand, the size-frequency distribution of craters—a very hard piece of data that is directly visible and measurable—tends to confirm the theory that among the smaller craters, the large ones are being eroded away by smaller impact craters.

If this process has been going on for most of the Moon's history, it may mean that a fairly deep layer of fine material has been produced on parts of the lunar surface.

This would be a process in which crater rims are ground down and the floors filled up with the material chipped off. As an example, a local accumulation running 100 ft. deep would be expected where there had been an old crater of about 1,000 ft. diameter. Local accumulations running from a few feet would be expected over much of the lunar surface.

In the case of the areas photographed by *Ranger IX*, it is noted that distribution of craters smaller than approximately 300 yards in diameter is about the same on the floor of Alphonsus and in the Mare Cognitum area photographed by *Ranger VII*. But for craters above 500 yards diameter, the floor of Alphonsus contains two or three times the number seen in Mare Cognitum.

Explanation for this is that the floor of Alphonsus is older than the mare, and therefore bears the record of more cratering events. The fact that below 300 yards in diameter the distribution is nearly the same means that up to that size, little craters are being eroded away by bombardment at the same rate at which they are being formed.

Mare Nubium, adjacent to Alphonsus, does not show craters less than 300 yards in diameter in the *Ranger IX* photographs because the pictures were not in high resolution for that area.

It would be expected that on still older parts of the lunar surface, the size of the crater that has not been obliterated by such erosion is larger than 500 yards. The bigger the crater, the longer time required to erode it away.

- **Crater variety**—The investigators agree that the *Ranger* photos show a number of different kinds of craters of distinct and characteristic shapes, and that craters result from three causes—impact, vulcanism and collapse of surface material into underlying cracks or voids. Beyond this, however, explanations of what is seen begin to diverge.

Besides the primary craters, there are others that are more complex, shallow, often elongate, with lower rims.

What appears to be a whole new group has been recognized. These are rather an indefinite type, circular in outline but showing varying depth and sharpness of form.

There is a type observed on the floor of Alphonsus and the maria, beginning with diameters of 100 ft. and becoming numerous in the size range of 500 to 1,000 ft.

These have been called "dimple" craters and there appear to be two kinds having the same general configuration—gentle, rounded walls, no rims, and an inverted bell-shaped profile—but with different floors. One floor is essentially flat, while the other narrows to a point or a sharp horizontal line.

In the opinion of two investigators, these craters may have resulted from the collapse or sagging of formerly molten material underlying the surface layer. In one case it is believed a cavity has collapsed, allowing surface material to drain off into a point or line. In the other, it is thought that underlying material has sagged but not broken, so that the floor of the depression remains flat.

In comparing the floor of Alphonsus with its walls, one of the experimenters sees possible support for the collapse crater theory. Noting that the floor has many more craters than the walls, including the relatively flat top portion of the walls, he says this may indicate that the walls show only impact craters, not collapse craters.

- **Landing risks?**—While the floor of Alphonsus closely resembles the maria, it is different in that it contains more craters, probably because it is an older feature. Nevertheless, the same investigator believes that at least half the craters shown in the maria in the three series of photos may be collapse features, again raising the question of landing hazards.

Another member of the photo-evaluation team believes the reason that there are fewer craters on Alphonsus' walls could be that there would be more tendency for the craters to slump and creep down the slopes. It is estimated that these terraced walls have a slope of 10 to 15 degrees. The slumping hypothesis would not hold true for the relatively flat top areas of the walls.

There is abundant evidence for collapse features on the floor of Alphonsus, where some rills were resolved into crater chains in closeup photos, the explanation being that the craters formed when material drained off into a crack.

While accepting the possibility that there may be collapse craters, another member of the investigative group argues against the idea that a layer of lava underlies the lunar surface material, although he believes some molten material may have existed on the Moon.

- **Lava theory challenged**—As possible evidence against the theory that the maria resulted from extensive lava flows, this scientist notes that in one of the *Ranger VII* photos, a wrinkle on Mare Cognitum runs through a crater, indicating that the wrinkle is not merely a surface effect such as a wave on a sea of lava. He finds it difficult to see how a crater could have been formed on such a wrinkle without disturbing it, or how molten material could have flowed in the area without eliminating the crater.

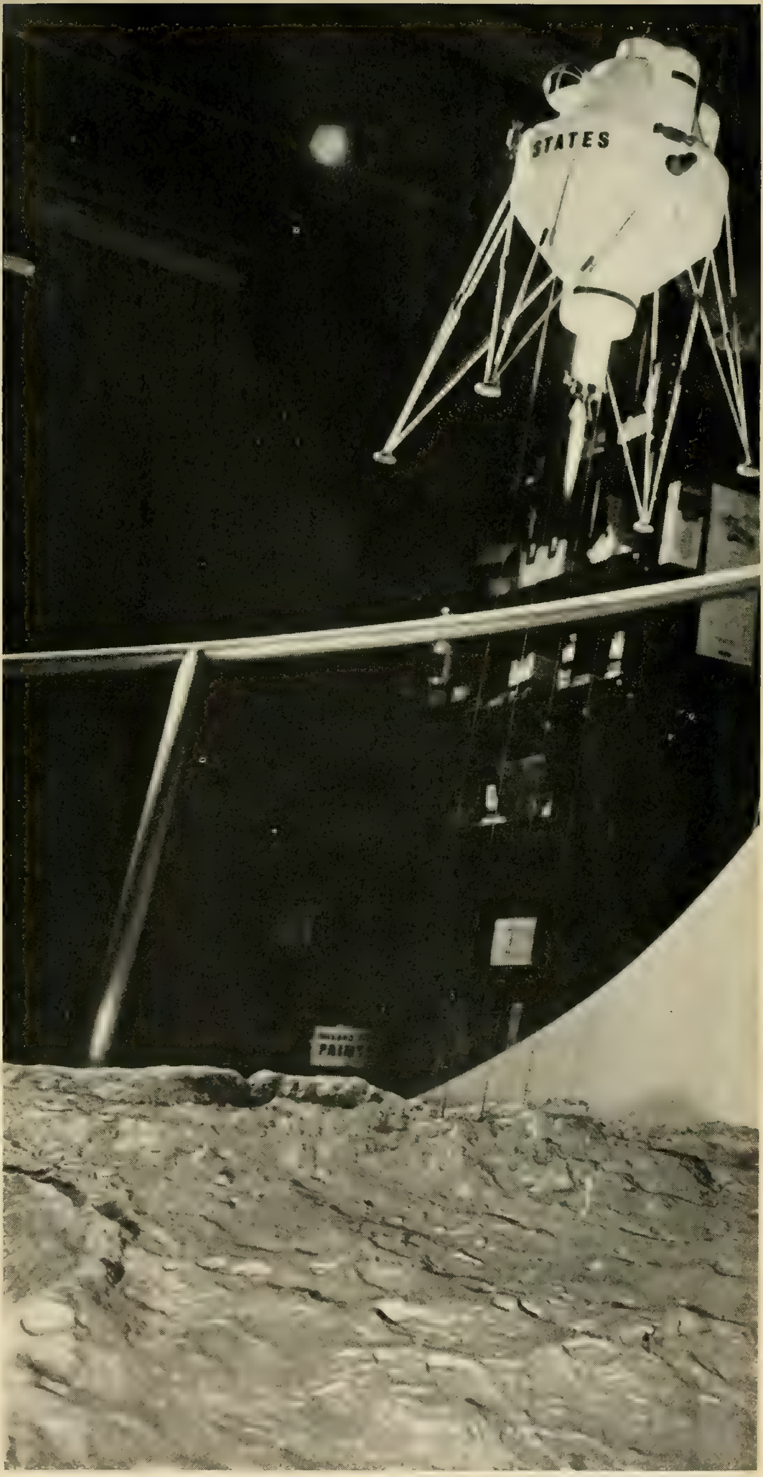
This experimenter proposes that the wrinkle may be due to water hydrating material in a crack, since it appears that a lighter line of material runs through the crater. If water hydrates certain materials, they swell and could produce such features.

- **Lingering disagreements**—While any interpretations at this point must be regarded as preliminary, it is apparent that scientists are split along predictable theoretical lines in their interpretations—and that these may not be greatly changed until *Surveyor* flights provide more information.

Most members of the photo-evaluation team believe they see a grid pattern encompassing numerous large and small features on the Moon, but two have reservations on this point. One said he believed the human eye arbitrarily tends to draw lines between features that seem to be aligned in the same general direction, thereby creating a grid pattern where none exists. The other believes the grid pattern exists, but that some observers tend to include details that may not be part of it.

At the same time, not all lunar scientists agree with the idea that the raised features of the grid are caused by molten material pushing up. There is a theory that the Moon was never molten, but accumulated from solid material. It has been argued by a number of observers in the past that if the Moon was formed in a molten state, its interior would still be plastic and could not support the body's slightly elongated shape. ■

(This is the second of a two-part special report on the now-completed Ranger lunar photograph program. Part 1 [M/R, April 5, p. 28] dealt in greater detail with the grid pattern of features on the Moon's surface and theories as to its origin.)



UTC Practices Lunar Hovering with Model

EXPERIMENTAL hovering hybrid model spacecraft in action at Sunnyvale, Calif., lab of United Technology Center, a division of United Aircraft Corp. Model employs a special method of reducing gravitational pull to 1/16 that of Earth's gravitational force. Operator controls model by remotely varying thrust of rocket motor.

From bioastronautics research
at Lockheed Missiles & Space Company:

A new biotechnology for Man-in-Space

and Man-in-Sea

Though the Astronaut and the Aquanaut will work in vastly different worlds, their basic problems are much the same. Biomedical problems like dysbarism (various gases trapped in the body), oxygen toxicity, anoxia, trace contamination. Psychological phenomena like "aloneness" (it can produce either depression or euphoria) and disorientation. Physical obstacles like the lack of an anchor point against which a man can brace himself to use many types of tools. By conducting studies in these common problem areas, Lockheed's Bioastronautics organization makes research dollars do double duty. Lockheed Missiles & Space Company, Sunnyvale, California: A Group Division of Lockheed Aircraft Corporation. **Lockheed**

gently does it... with electrochemical machining by Ex-Cell-O. ☐ ECM is the fast and gentle way to finish-machine conductive aerospace materials such as those shown here. The tool (electrode) never touches the surface. Thus, there's no stress or tool marks, no burrs or heat checks, no distortion in thin-wall sections. A consistent finish within 3 to 10 micro-inches is possible, depending upon material. ☐ Most difficult configurations can be met in a single pass because ECM permits three-dimensional machining. Result: Ex-Cell-O helps you reduce lead time on experimental and prototype models, saves you valuable time on production runs. And accuracy meets the severest aerospace requirements and mil-specs. ☐ Got a tough space-age material that needs finishing? Now you know where to get the job done promptly, economically . . . and gently. ☐ *Flight and Space Division, Ex-Cell-O Corporation, 1200 Oakman Blvd., Detroit 48232.* 65-36 PD

Flight & Space Division XLO | EX-CELL-O

Integral airfoil vanes in turbine nozzle of Inconel 718 formed by Ex-Cell-O using ECM method. Band tolerances held within .004".

Blades of Udimet 700 with holes machined by Ex-Cell-O to precise tolerances using ECM method.

Fuel line cruciform of Hastelloy "C" has parallelism, concentricity and thickness held within .004" band tolerances by Ex-Cell-O using ECM.

Ex-Cell-O used ECM to drill 198 holes simultaneously in burner plate of 304 stainless steel, accurate to ± .0015".

MAN AND MISSILES FLY HIGHER, FASTER AND SAFER WITH PARTS AND ASSEMBLIES BY EX-CELL-O AND ITS SUBSIDIARIES XLO

Wound Tungsten Offers New Shapes

UTC process employs tungsten wire bonded with plasma-sprayed tungsten; nozzles built using technique exhibit superior re-start capabilities

by John F. Judge

SUNNYVALE, CALIF.—A new route to tungsten structural shapes is in the development phases at United Technology Center, a division of United Aircraft Corp.

The process involves winding tungsten wire, or filaments, around a mandrel while simultaneously bonding the wires with plasma arc-sprayed tungsten.

Initial efforts have been directed toward nozzles, and several configurations have been fired over the past two years. The wires act as reinforcements for the plasma-sprayed tungsten matrix.

The wire-wound tungsten composite is the invention of Dr. R. G. Cheatham at UTC. The work is a continuation of Cheatham's efforts at Materials Technology Labs, a firm he founded and portions of which have been acquired by UTC.

With respect to nozzles, the tungsten composite has several advantages over both forged and powder metallurgical processes:

—The material and process is not size-limited. Any size mandrel can be used.

—No machining is required. The internal contours are essentially established by the mandrel, and the thickness of the material can be varied at will on the same piece. (In this manner the throat area can be thicker while the entrance and exit sections of a given nozzle can be considerably thinner. It is even possible to wind in flanges, which can act as stiffeners.)

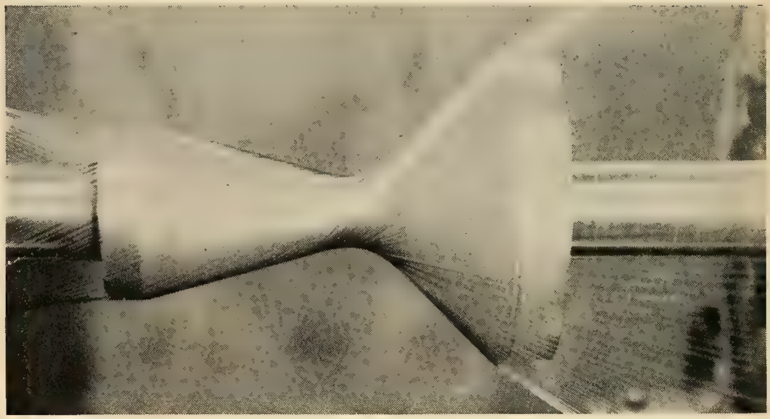
—No sintering or heat treatment is necessary, eliminating the need for costly equipment and time-consuming operations.

—The material exhibits excellent structural stability in fabrication because residual stresses are minimized and it is fabricated directly to size.

—The material exhibits excellent stress resistance and resists crack propagation because of its reinforced structure.

—The material has good oxidation and corrosion resistance because of the high density and lack of grain boundaries in the filamental wire.

- **Firing tests**—In February, 1963, a nozzle throat 1.2 in. in diameter was fired for 130 seconds at 800 psia using a 5700° PBAN (aluminized) propellant. No measurable erosion occurred.



TUNGSTEN WIRES are helically wrapped around a mandrel prior to the introduction of the plasma-sprayed metal.

A second firing in March, 1963, under the same ballistic conditions used a nozzle with the entrance section, throat and expansion wound in one monolithic piece. The free-standing expansion cone had its outside surface exposed to the oxidizing atmosphere for the 130-sec. firing time. Again there was no measurable erosion and no evidence in either firing of grain growth or recrystallization.

Two additional firings were held in July, 1963, using a 6800°F hybrid propellant system to check out the tungsten wire-wound nozzle in high temperatures. In both of these tests, steady chamber pressure curves were maintained until melting and total eviction of the nozzles occurred. In one firing this happened after 15 seconds and in the other at 13 seconds.

A series of firings in December, 1963, were scheduled to determine the resistance of the wire-wound nozzles to multiple re-start conditions. Here the nozzles are exposed to high stresses through thermal cycling. Tungsten is a fairly brittle material, and this is a problem with conventional shapes.

A single 0.4-in. nozzle was subjected to ten 20-second firings, each from ambient temperature conditions. The chamber pressures were between 680 and 750 psia. No erosion was found.

- **Comparison firing**—The last test was conducted to determine the resistance of the material to high heat fluxes. In July, 1964, two motors were fired, one containing a 1.2-in.-dia. tungsten-wound nozzle and the other a CFW graphite nozzle.

The tungsten nozzle did not erode after a 27-sec. test. The motor pressure was above 1,000 psi for 10 seconds of the firing and at 1,740 psi for about 2 seconds.

The graphite nozzle was catastrophically ejected after only 9.7 seconds under these same conditions.

The tests demonstrate the ability of the tungsten approach in nozzles to handle pulsed motor firings. In addition, Cheatham says other materials can be wound or sprayed into the nozzle during fabrication. This might take the form of a lower melting metal near the nozzle interior surface or as the matrix in this area to permit a form of transpiration cooling.

Tantalum metal can be used to act as a carbon barrier. It is also possible to wind-in or spray neutron blocking materials for nuclear applications. ■

Air Force Seeking Data on Toxicity Of Materials for Use in Space Cabins

by Heather M. David

SIGNIFICANT DATA are being returned from tests conducted by the Air Force on the toxic effect of various materials in space cabin atmospheres.

One of the most interesting of the results thus far is the comparison of the effects of space cabin trace contaminants when in a 5-psi, pure oxygen environment to those in the oxygen/nitrogen, sea-level-pressure atmosphere. The 5-psi, 100% oxygen system has been chosen for *Gemini* and *Apollo*, and is a leading contender for the *Manned Orbiting Laboratory*.

The Air Force will initiate a one-year test of the 100% oxygen atmosphere—without contaminants—using 12 trained Macaque monkeys to settle once and for all the question of the possible deleterious effect of this atmosphere in itself. This test will provide a baseline for future testing on toxic materials in the spacecraft environment.

Aerospace Medical Research Laboratory toxicologists have a list of some 500 materials, which will then be tested to see if they can safely be used in spacecraft design. Physicians are concerned that materials used in the closed cabin could outgas and build up to levels that might poison the astronauts.

• **Different reaction**—In preliminary tests of two weeks' duration, the Air Force group has found that animals respond differently to irritating compounds in the pure oxygen, low pressure environment than they do at sea level.

Three compounds, like those that might occur if leaks of fuels or oxidizers should seep into a spacecraft cabin, were chosen for preliminary tests. These effects were noted:

—Carbon tetrachloride, a substance toxic to a living organism with a whole-body effect, had a slightly increased effect in the 5-psi, oxygen environment.

—Nitrogen dioxide and ozone, contaminants that are irritating to the lungs rather than to the whole body, were slightly less toxic than at sea level pressures. The doctors concluded that there is a definite reduction in toxic response to pulmonary irritants under reduced pressure as compared with ambient.

Another series of tests to discover the mechanism for this difference has been initiated, including identical tests, but at sea-level pressure, with oxygen partial pressure at 255 mm Hg (the same as in the 5-psi atmosphere). This would mean an approximately 35% oxygen, 65% nitrogen mixture at 14.7 psi.

• **One year test**—This 12-month test with no contaminants scheduled to begin shortly will use trained Macaque monkeys. By comparing their performance of certain tasks over certain time periods and with some biological measurements, the scientists hope to find out whether the artificial atmosphere of pure oxygen at ⅓-atmosphere could in itself prove to be a toxic factor in long space trips.

The group already has run a 90-day experiment on pure oxygen, with the conclusion that there were no significant effects. However, some physicians still are opposed to the use of this environment for any length of time.

• **Contaminant testing**—After baselines are established, the effects of the spacecraft materials will be compared. Toxicologist Dr. Kenneth Back told MISSILES AND ROCKETS that various animals will be exposed to mixtures for 90-day periods. The materials will be injected into the main atmosphere in the same concentrations as if they were leaking from fuel reservoirs or outgassing from equipment and components in the cabin.

Later, the Air Force hopes to use actual space cabin life support equipment in the closed chambers, to see how well it can maintain the atmosphere within the cabin, as well as to determine whether the equipment itself produces any toxic emanations.

The Air Force began its work in this field about five years ago when spacecraft designers began requesting guidelines in their choice of materials. The group of scientists at Wright-Patterson AFB, led by Dr. Kenneth G. Back and Dr. Anthony Thomas, began testing the effect of the then accepted industrial limits of concentrations to see what occurred if animals were exposed to these for continuous periods. These figures, called Industrial Threshold Limit Values, had been set for eight-hour days, and no data were available for the space cabin type situation.

The toxicologists chose a number of contaminants that presumably might be found in a space cabin and exposed animals to them in the so-called acceptable doses. Most of the animals died—none from the same reasons. This led to a long series of tests, in which each contaminant was tested separately. Most of the industrial levels had to be thrown out the window, and design criteria revised as it was found that one or more of the compounds caused unacceptable effects.

The laboratories also are responsible for setting limits for exposures to missile fuels. An interesting factor in early testing was the conclusion that hydrazine is a much more dangerous compound that UDMH, although the Industrial Threshold Limit Value was twice that of UDMH.

Equipment used in the early studies was found to have a number of limitations, including the fact that the tests had to be interrupted while the animals were tested or housekeeping chores performed. This led to design of the new equipment, which was built by Aerojet-General Corp. under a $1.5-million three-year contract.

• **Facility description**—The laboratory complex consists of four domes, 12 feet in diameter and 9 feet high. Each dome is of glass window and metal beam construction, so that the experiments are visible from all angles.

Top portion of the domes can be separated and hoisted to the ceiling to permit loading of cages and animals or other equipment. The chamber is then sealed with an O-ring. Altitude capability of each chamber is 28,000 ft., to simulate the 5-psi atmosphere of most planned manned spacecraft.

The atmosphere within the chambers can be maintained continuously, even though tests and samples are being taken from the animals inside. An airlock directly below each chamber allows egress so that technicians and scientists may enter the chambers to perform medical testing, feeding and waste disposal.

Control of the operation is automated to the extent that a single technician can run the facility when tests are not in progress. A Honeywell control panel maintains oxygen-carbon dioxide levels, oxygen flow rate, temperature, contaminant flow, absolute pressure and dew point within each dome.

Considerable redundancy, including triple vacuum pumps, have been provided so that no experiment will be lost because of equipment breakdown. Other backup systems are provided for air conditioning, oxygen heaters, air compressors, and electrical power. Visual and audio alarms are provided to detect imbalances in the preset environment.

A penetration plate contains connections for a water flush system and drinking water for dogs, a sampling port, hardline communications, 24 pair of shielded cable for biological signals, and a pressure sensor.

- **Safety measures**—The hazards of working at high altitude require precautionary equipment and procedures. A 60-minute denitrogenation period is required to prevent possible bends while performing work at the ⅓-atmosphere altitude. While entering the airlock, technicians must breath from a walk-around oxygen bottle. When the airlock is closed, he reconnects to the permanent oxygen supply, purges the lock until it reaches 98% oxygen and begins depressurization to 5 psi. Descent time after the altitude exposure in the dome is four minutes in the airlock. In the event of a fire, the dome can be repressurized in 15 seconds by a dump valve, which is redundant for inside and outside operation.

Oxygen is supplied to the domes through a converter-heater, which supplies gaseous oxygen at 50 psi pressure and 72°F. Liquid oxygen storage is 68,000 pounds. A high-pressure blower supplies filtered and preconditioned outside air, which is used rather than gaseous nitrogen for those mixtures of oxygen-nitrogen. Only oxygen is then pumped in to achieve the balance desired.

Leak rate is kept below 0.5 lb. per four hours in a static condition with 10 psi differential, permitting a 98% oxygen content at 5 psi, with a flow of only 18 cfm of oxygen.

Various contaminant generating systems for liquids, gases, solids and dusts are contained in the basement equipment area. The material is metered into the oxygen or oxygen-air flow in hard set quantities. Through continuous monitoring and three wet chemical analyses per day, a not more than 10% deviation of actual to nominal contaminant level is achieved.

Spectrophotometry and gas chromatography are used to maintain and test dome environment. ■

Douglas Simulator Passes Two Tests

MANAGEMENT OF trace contaminants in two recent manned space station simulations at Douglas Missiles and Space Systems Div. at Santa Monica, Calif., was accomplished by use of a toxin burner developed for Douglas by MSA Research.

The effective control of such contaminants was an important part of the two tests, which ran 12 and 30 days early this year. The toxin burner consisted of an assembly of catalytic beds, charcoal and other chemical filters, and an electric heater and heat sink system.

During the tests, in which four men were maintained in an oxygen-nitrogen atmosphere at 7 psi, the crew carried out space station tasks and evaluated prototype equipment. Although Douglas scientists have made only preliminary analyses, they report good results in qualification of the facility and some of the equipment.

Carbon dioxide was removed from the closed cabin through use of a molecular sieve subsystem provided by the Tapco division of Thompson Ramo Wooldridge. Another TRW unit for thermal control utilized Coolanol 25 as a heat sink. CO_2 was maintained within 0.6 to 1.2% of the atmosphere by volume for the most part, but on three instances rose to 1.65% for short durations. These moments occured during a small fire in the cabin, during a leakage in the waste management system, and when a valve in the CO_2 control system malfunctioned.

Among the equipment being evaluated was a "shirt-sleeve" garment for use in a space station situation. However, Douglas engineers concluded that some improvements could be made in the design. Another new development was a sleeping cot made of nylon net, with nylon and cotton sheets and acrilan and cotton mattresses.

Food was consumed three times a day and consisted of freeze-dried meals with powdered beverages reconstituted with water.

Physicists and Electrical Engineers for research into

NEW COMPONENT PART CONCEPTS

Unusual opportunities now exist in the field of component development and performance analysis, due to a conceptual approach developed by our Research and Development Laboratories. These positions demand the ability to perform laboratory evaluation on existing components and prepare a critical analysis of their performance. Where the state of the art is a limiting factor, new approaches must be proposed and development work initiated to provide the required component performance.

In the process of developing new approaches to the solution of component problems, papers must be prepared which will be used as the basis for proposals.

Well equipped laboratories are provided in which the applicant can employ the latest techniques in development and instrumentation to assist in the exploitation of his ideas.

Qualifications should include at least a BS degree from an accredited university in Physics or Electrical Engineering. In addition, the applicant must be able to demonstrate 5 to 10 years of progressive creative experience through issued patents or publications in technical journals.

Please airmail your resume to:

MR. ROBERT A. MARTIN
Head of Employment
Hughes Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 47, California

Creating a new world with electronics

HUGHES
HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS

An equal opportunity employer.

CO-PILOT

Today's Minuteman is more than a super-reliable missile.

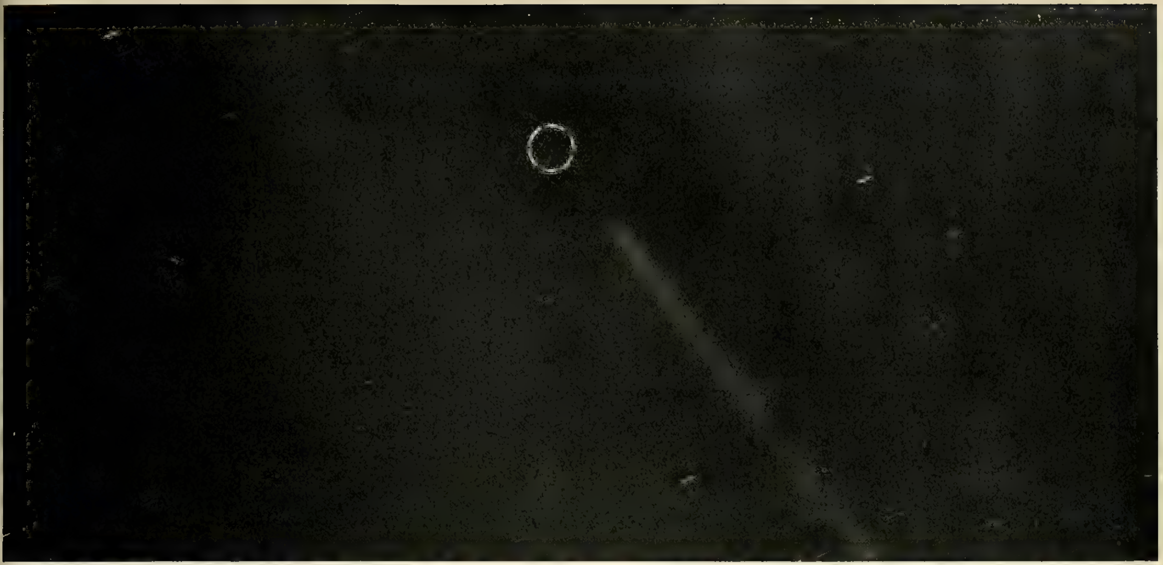
It is a spearhead of electronics progress—technology that is making it a co-pilot by proxy in low-level supersonic aircraft.

It is the forerunner of microelectronic low-level penetration systems by NAA/Autonetics that spot and evade obstacles with unprecedented accuracy. These new NAA/Autonetics systems are based on proven Minuteman techniques and systems management experience.

Autonetics built the fully-integrated microelectronics systems in Minuteman II; was the first to apply microelectronics to production-line systems. Its achievements in this field are setting a whole new standard of reliability in the electronics industry.

For more information about Autonetics total systems capability in meeting the electronics needs of the future, please write: Director of Marketing, NAA/Autonetics Division, 3370 Miraloma Avenue, Anaheim, Calif.

North American Aviation Autonetics Division



BACKSCATTERED light from laser beam points to orbiting satellite located within dashed circle.

Benchmarks in Space Can Aid Mapping

Air Force using laser beam to photograph Explorer 22; technique could lead to better geodetic mapping, more precise targeting

by William S. Beller

AIR FORCE scientists recently snapped the first pictures of an orbiting satellite illuminated by a laser beam, possibly ushering in a new era in geodetic mapping.

This work, leading to precision mapping of much of the world, could have important military applications. Accurate knowledge of the coordinates of military targets could, for instance, significantly reduce the warhead weight of long-range missiles.

NASA's Polar Ionosphere Beacon satellite (*Explorer 22*), equipped with corner reflectors and launched last October, gave geodesists at an Air Force laboratory a datum point in the sky. Even though it orbits and is more than 900 nautical miles above the Earth, it is considered as good as the most precise benchmark a surveyor could establish on the face of the Earth. Moreover, it can help establish the geodetic coordinates of any place on Earth that can observe the satellite by the light of a laser.

Three men at the Office of Aerospace Research's Cambridge Research Laboratories (AFCRL), Bedford, Mass., devised the experiments to capture *Explorer 22* by photographic means. With their equipment, Robert Iliff, Capt. Michael Tavenner and Theodore Wirtanen, successfully photographed *Explorer 22* in a laser beam three times, all the shots in 1965. At the same time, they caught the satellite photoelectrically. Next week they intend to try again.

No other laboratory is known to be doing such work. Most are using the laser return simply as a highly accurate way to track the satellite. Still experimental, this tracking technique is of considerable interest to both NASA and the Air Force.

- **Largos explained**—The method AFCRL has in mind for getting precise coordinates of positions on Earth is based on Largos—Laser Activated Reflecting Geodetic Optical Satellite. Suggested by Tavenner at the 1962 meeting of the American Geophysical Union, Largos calls for at least two ground stations, one with known coordinates. Each would simultaneously photograph in laser light the beam reflected by the corner reflectors of an orbiting satellite. The distance from each of the stations to the satellite would be found from the time taken for the laser beam's round-trip.

With the star background showing in each of the pictures, an analyst would first pinpoint the location of the satellite with respect to the known station. With this information he could then quickly find the precise coordinates of the unknown station—or stations, if several are involved.

This method borrows from the "orbiting beacon" portion of the *ANNA* satellite—a joint project of the Army, Navy, NASA and Air Force. On ground command, the beacons flash and are photographed against stellar backgrounds. Largos merely replaces the sophisticated electronics, power source and beacons on the satellite with passive reflectors and puts the light source on the ground.

AFCRL scientists point out that Largos has the added attraction of giving range information, an equivalent to another observation. This means that while the beacon portion of *ANNA* requires two positionally known stations to pinpoint the satellite, Largos requires only one. Based on *ANNA* experience, the AFCRL scientists expect to be able

MOTION MEASUREMENT REPORT CEC

REPORT NUMBER 1

New miniature crystal accelerometer eliminates the 6 biggest problems in measuring vibration.

ROBERT H. GODDARD
U.S. AIR MAIL 8c

CEC's Type 4-281 Piezoelectric Accelerometer, the latest refinement of the low-output-impedance concept pioneered by CEC, makes measuring dynamic acceleration easier and more precise than ever before. The miniature 4-281 solves the 6 major problems familiar to every user of piezoelectric devices:

Impedance Matching...No external electronics are required; low-impedance output is preconditioned for direct readout.

Cable Capacitance...No capacitance-vs-output calculations are needed; performance is independent of cable considerations.

Sensitivity Variation...Voltage sensitivity is constant from system to system, application to application.

Mass Loading...No penalty in size and weight, the 4-281 is as small and light as most conventional piezoelectric accelerometers.

System Noise...Low noise at the output achieves exceptionally high signal-to-noise ratio (less than .05 g equivalent).

Case Sensitivity...No "breeze disease" or other case effects; the sensing element is physically isolated.

And that's just the beginning of the story. The 4-281's "compliant rod" sensing element and source follower are *electrically and mechanically isolated,* enclosed in an all-welded stainless steel case. In addition, the new accelerometer contains a built-in voltage insertion circuit for functional checkout and system calibration, as well as an integral connector and detachable mounting stud.

Unequalled by any other instrument in the world today, the following specifications show how the 4-281 can make your measurement task easier and more productive:

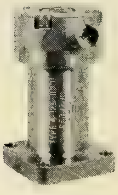
- Basic Voltage Sensitivity—30 mv/g nominal.
- Output Impedance—150 ohms max.
- Frequency Response—4 to 10,000 cps ±5%.
- Acceleration Range—Up to 100 g.
- Cross-Axis Sensitivity—3% max. in any axis.
- Temperature Range—−100°F to +300°F.
- Noise—3 mv p-p max.
- Mass—Less than ⅓ cubic inch; less than 1 oz.

The 4-281 is a case in point why CEC has become the acknowledged leader in the field of motion measurement. *Only* CEC offers a complete line of transducers for measuring static and dynamic acceleration, vibration, and shock. Furthermore, *all* of these are standard products which may be readily modified to meet special requirements.

This growing family of proven performers now consists of:

TYPE 4-274
PIEZOELECTRIC
ACCELEROMETER

TYPE 1-303
CHARGE
AMPLIFIER


TYPE 4-125
VIBRATION
TRANSDUCER

TYPE 4-202
STRAIN GAGE
ACCELEROMETER

- **Miniature piezoelectric accelerometers and amplifiers,** high sensitivity to low output impedance, source followers to charge amplifiers.
- **Strain gage accelerometers,** high g to low g, 1 axis to 3.
- **Velocity transducers,** from miniature to high temperature, linear and rotary.

For complete information on the 4-281, call your nearest CEC Sales and Service Office or write for Bulletin CEC 4281-X11.

CEC
Transducer Division

CONSOLIDATED ELECTRODYNAMICS
A SUBSIDIARY OF **BELL & HOWELL**/PASADENA, CALIF. 91109
INTERNATIONAL SUBSIDIARIES: WOKING, SURREY, ENGLAND
AND FRIEDBERG (HESSEN), W. GERMANY

Circle No. 7 on Subscriber Service Card

to locate a reflector-equipped satellite in space within five meters of its actual position.

"Within the next two or three years, we'll probably see rugged equipment actually in the field making precise geodetic measurements," Owen W. Williams, chief of AFCRL Terrestrial Sciences Laboratory, told MISSILES AND ROCKETS. He was basing his comment on the part *Explorer 22* will play in the scheme.

The quest of geodesists is to have a major network of precise positions related to the Earth's center of mass. "Once we have this network or skeleton, we can hang some flesh on it," said Williams.

The network would lead to an accurate mathematical model of the shape of the Earth. With this, geodesists could relate one area on the Earth to another with great precision. The equation, a converging series with scores of terms, would be derived and handled by a computer.

- **Small ICBMs**—The effect of this equation on the size of strategic missiles could be easily calculated. It would relate the increased accuracy of target coordinates to the decreased warhead size needed to destroy a target.

Major General Don R. Ostrander, OAR Commander, recently gave an example of this relationship: "If you can reduce your circular error at impact by a factor of two—say, from one mile to one-half mile—you can reduce the explosive force required for target destruction by roughly a factor of 10. In other words, you can reduce your warhead from the megaton to the kiloton range." This could correspondingly lead to smaller missiles with enough weight left over to better the accuracy of the guidance system.

The Largos system for getting geodetic data is inexpensive. All that is lost when the satellite's orbit decays is the reflector system. The rest of the geodetic equipment is safely on the ground.

From a technical point of view, two advantages of Largos stand out. First, the satellite system of corner reflectors is passive; there is no call for satellite power. Furthermore, there is no need to tell the satellite in advance to flash its lights (as with *ANNA*), with, perhaps, the satellite's power wasted should a cloud cover negate the experiment.

The second advantage is the ability to control the entire experiment from the ground. If something should happen to the laser mechanism, for instance, it could be repaired with, at most, a trip back to the factory that made it.

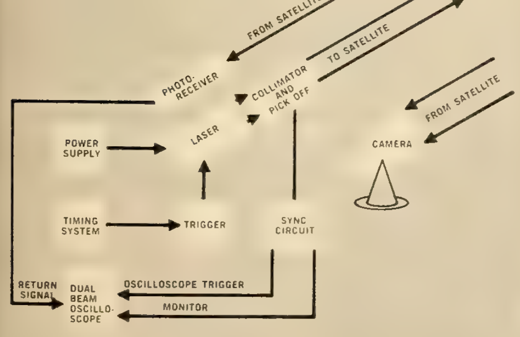
- **Photographing a satellite**—The operators of the laser photographic system first set the azimuth and elevation of their camera to the predicted look angles of the satellite. Then the laser is fired milliseconds in advance of the satellite in order to hit it at the time calculated for the look-angles. The camera shutter is opened about 20 seconds before the shot and remains open until after the laser is fired.

The success in catching the satellite on a photographic plate, even though the laser beam measures only 15 minutes of arc, speaks well for the accuracy of the look-angles furnished by the Air Force's Space Track facility at Bedford, Mass., part of SPADATS. In fact, some Air Force officials are regarding Space Track look-angles with new respect.

The angular speed of the satellite seen from the Earth's surface can be as great as 25 arc-minutes per second. This means that the satellite traverses the diameter of the laser beam in only 0.6 sec. Since the laser is triggered by a clock accurate to 0.1 millisecond, the laser, even with its narrow beam, is able to catch and illuminate the satellite. The 0.5-sec. delay between triggering and laser action, and the usual 3 to 4-millisec. propagation time to reach the satellite, are considered in the triggering time.

The total aiming error resulting from alignment of the optic axis with respect to a reference azimuth, instability of mounting, instability of collimeter, shifting of the ruby crystal, cross-axis error, and elevation-axis nutation error is estimated to be two minutes or less. This is said to be a satisfactory aiming error for rugged, portable field gear of this nature.

BLOCK DIAGRAM of the Largos Concept.



- **Equipment description**—The laser system used was designed and built by Edgerton, Germeshausen and Grier, Inc., of Bedford, Mass. It is described as a dual cylinder with two Xenon flashtubes and a 6 x ⅝-in.-dia., 90-degree orientation, ruby crystal. The reflectors are polished sheet aluminum, rolled to fit the cavity. This setup is considered to save time and money because the reflectors can be exchanged quickly, easily and cheaply in the event of a gross failure. Moreover, the length of the cavity may also be changed to accommodate various crystal lengths.

The laser power supply is able to store 10,000 joules for each lamp and uses pulse-forming coils to give a square wave, limiting peak current to the lamps. The ruby is cooled to near liquid-nitrogen temperature by forcing liquid nitrogen through the crystal holders. Experiments showed that the temperature of the center of the crystal was within 10°K of liquid nitrogen 15 minutes after starting to cool.

The camera used to photograph the images is a geodetic stellar camera. It has a 1,016-mm focal length and a 203-mm aperture with a 10 x 10-degree field-of-view. Developed by the Instrument Corp. of Florida for AFCRL for the *ANNA* project, the camera has lenses color-corrected much further than normal into the red region of the spectrum.

The image of the satellite, caught on glass plates coated with Kodak 103-F emulsion, ranges between 30 and 60 microns in diameter. This is the interval particularly useful for geodetic work. A "blob," although more dramatic, would not be sufficiently precise.

Asked about future plans for the laser system, Williams said he would like to see the satellite photographed several times during each pass instead of just once. This means going into nanosecond bursts of laser pulse instead of the present 2.7 milliseconds, and cooling the Xenon tubes by some sort of pumping technique. In this way, the apparatus may be able to fire three to five times during the 15-second window to the satellite.

GEOS, the first all-geodetic satellite and a joint NASA-DOD project, when it goes into orbit this summer, will have corner-cube reflectors, flashing beacons, doppler, a SECOR radio transponder, and a NASA range and range-rate system. The reflectors and beacons will be enough to tell AFCRL experimenters how laser photography compares with the *ANNA* technique for accuracy. The Air Force scientists expect the tests to reinforce their strong belief that laser photography will be the next major step taken in geodetic mapping. ■

Engineers and Scientists are invited to inquire about the professional openings available immediately with General Electric on the Apollo Program

apollo
apollo
PROGRAM

HUNTSVILLE, ALABAMA

Experience required in the following areas:

Systems Design Engineer **BSEE**	Conceptual, functional and preliminary design of electrical subsystems and hardware of ground support equipment for launch vehicles. Should include computer applications, digital circuitry or control systems design.
Systems Engineers-Power **BSEE**	Analysis of power requirements of stage and missile systems and/or launch complex areas. Conceptual, functional, preliminary design of ESE equipment as applied to launch missile stages.
Systems Interface Engineers **BSEE**	Experience in design and evaluation of complex electrical GSE with interface coordination experience. From available documentation analyze, formulate, and document the various interfaces (vehicle/GSE, GSE/GSE) and formulate functional circuit schematics.
Electrical Engineer-Reliability Analysis-BSEE **(Also for Cocoa Beach, Fla.)**	Design, test or analysis of electrical systems, with at least two years in failure mode and effects analysis, determination of criticality numbers, or development of math models. Coordinate analytical effort with design and test personnel.

HOUSTON, TEXAS

Experience required in the following areas:

Crew Systems Engineer **BSAE, ME**	Analysis of systems required for support and operational use of spacecraft crew; in development of specifications, test plans and requirements for crew systems; and knowledge of crew capabilities and limitations.
Engineer, Failure Data (or Analysis) **BA/BS, Math, Physics or Engr'g.**	Analyze failure and use data for parts and materials. Perform assessments of parts and materials reliability. 5-10 years experience in defense industry parts and materials qualification testing and analysis. Familiarity with mathematics of test data report handling (plot trends).
Engineer-Cryogenics Fuel Cell **BSME/ChE.**	3 to 5 years experience in work involving Cryogenics, Fuel Cells and associated systems. This should include systems design and analysis. Provide technical assessment of design of Apollo SC systems emphasizing reliability.

DAYTONA BEACH, FLORIDA

Experience required in the following areas:

Computer Programmers **BS Math, Engineering**	Large scale computer programming of applied math and engineering problems. Experience in technical data processing and/or information systems desired.
Documentation Specialists **College Degree** **(Also for Cocoa Beach, Fla., if design exper. strong.)**	Analyze, determine and define Apollo engineering documentation standards and practices requirements necessary to achieve Department objectives. Five years in Engineering Documentation; familiarity and experience in DOD policies; contract; specifications and technical manuals, regulation and writing; plus actual knowledge of large systems preferably missile and/or aircraft.
Engineer-Operational Analysis **BSME, AE, CE, IE**	Develop systems management procedures and system analysis of launch facilities and equipment. Minimum 2-3 years experience preferably in similar aerospace program. Must deal with customers, know and be able to document all functions, authorities, responsibilities of organization and information flow. Require familiarity with AFSC 375 series system and government documents.

contact MR. D. D. SMITH / PROFESSIONAL & TECHNICAL RESOURCES
G.E. / Apollo Support Dept. / Room 1111-P / Box 2500 / Daytona Beach, Fla. 32015

APOLLO SUPPORT DEPARTMENT
Missile & Space Division

GENERAL ELECTRIC

An equal opportunity employer.

Circle No. 8 on Subscriber Service Card

The Industry Week

Report Criticizes Interlocking Management

Rep. Emanuel Celler (D, N. Y.) has called for consideration of legislation to do away with interlocking management in aerospace and other companies. Celler's action followed recent issuance of a House Judiciary Committee staff report on such management practices. The report concluded that interlocking management results in impairment of the competitive ability of two firms employing managers in common. The report also declares that interlocking management reduces the effectiveness of any manager serving in several positions at the same time. Five aerospace firms, General Dynamics, Lockheed, North American Aviation, United Aircraft and Douglas, were cited in the report as examples of corporate interlocks. Douglas, for example, has 15 directors interlocked with managements of 17 banks and other financial institutions, one insurance company and 28 industrial-commercial corporations, including Cohu Electronics, Giannini Controls, and Richfield and Tidewater oil companies.

Mergers and Acquisitions

Marquardt Corp. and General Applied Science stockholders have approved the merger of the firms. The plan calls for Marquardt to acquire the business and net assets of GASL for approximately 288,000 shares of Marquardt stock. GASL, Westbury, N.Y., which is active in research and development in the hypersonic combustion and ramjet design fields, will function as a subsidiary of Marquardt. . . . *Condec Corp., Stamford, Conn., has acquired the business and assets of Astronetic Research, Inc., Nashua, N.H. AR has specialized in the design and manufacture of miniaturized power conversion systems for aerospace application and will become the Astronetic Research Dept. of Condec's Consolidated Avionics Div. in Westbury, N.Y. Consolidated Avionics is in the solid-state power supply business.* . . . General Time Corp. has announced its intention to buy for an undisclosed amount of cash part of Elgin National Watch Co.'s defense business. Included in the transaction will be Elgin's production of elapsed-time indicators. . . . *Dielectric Products Engineering Co., Inc., Littleton, Mass., has acquired the assets and product line of Electronautics Corp. of Maynard, Mass. To be operated as the Electronautics Div. of Dielectric Products, the acquisition will manufacture microwave power absorbing materials, elements and dummy loads. Dielectric makes microwave antenna systems and components for the radio communication, radar and broadcast industries.* . . . Barden Corp., Danbury, Conn., manufacturer of precision instrument ball bearings, has purchased the stock of American Powdered Metals, Inc., North Haven, Conn. The move is part of Barden's diversification program to put the company into commercial non-defense markets. APM will be operated as a wholly owned subsidiary under its president, Gerald Fellows. . . . *Radio Corp. of America has terminated negotiations for acquisition of Prentice-Hall, Inc. The two firms were reportedly unable to reach a mutually satisfactory basis for the transaction.*

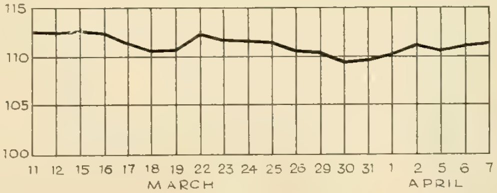
New Facilities

Air Products and Chemicals, Inc., Allentown, Pa., plans to construct an oxygen plant at Granite City, Ill. The facility will triple the production capacity of Air Products and is intended to supply requirements of a basic oxygen steelmaking shop now under construction by Granite City Steel Co. Completion is expected in January, 1967. . . . *Raytheon Co.'s Semiconductor Operation, Mountain View, Calif., is planning to expand its integrated circuit manufacturing facilities. The firm will add 20 diode-transistor-logic devices to its present line of direct-coupled-transistor-logic integrated circuits.* . . . U.S. Polymeric Chemicals, Inc., manufacturer of pre-impregnated composite materials for missile/space and industrial use, has purchased 5.11 acres and all buildings formerly leased at 700 E. Dyer Rd., Santa Ana, Calif. The $675,000 acquisition will provide for further expansion of the firm's Santa Ana facilities. . . . *Greer Hydraulics, Inc., Los Angeles, is establishing a new rubber facility to speed research into missile/space applications of the firm's line of energy-storing hydro-pneumatic accumulators.*

International

Page Communications of Canada Ltd. and DCF Systems Ltd. of Ontario have formed an association to enable them to bid on communications systems on the international market. Page is a subsidiary of Page Communications Engineers, Washington, D.C., a subsidiary of Northrop Corp. and DCF is a wholly owned subsidiary of de Havilland of Canada Ltd. . . . *LFE Advance Components, a division of Laboratory for Electronics, Inc., Waltham, Mass., has received a contract from Mitsubishi Electric Manufacturing Co. Ltd. to build the delay system for a radar Mitsubishi is building for the Japanese defense ministry.*

Missile/Space Stock Index



STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

AWARDS

AIR FORCE

$12,173,918—**North American Aviation, Inc.,** Anaheim, Calif., for spare parts for *Minuteman* missiles.

$3,596,799—**Collins Radio Co.,** Cedar Rapids, Iowa, for work on communication systems.

$1,221,340—**Atlantic Research Corp.,** Alexandria, Va., for *Arcas* sounding rockets.

$229,428—**Oklahoma State University of Agriculture and Applied Science,** Stillwater, Okla., for research leading to development of instrumentation in research rockets.

$69,675—**Georgia Tech Research Institute,** Atlanta, for experimental research program to develop an electromagnetic window for reentry vehcles.

$52,410—**Planning Research Corp.,** Los Angeles, for study of defense against attack by ballistic missiles.

$50,000—**Thiokol Chemical Corp.,** Reaction Motors Div., Denville, N.J., for research on elastometic and compliant materials resistant to liquid rocket fuels and oxidizers.

$48,900—**Goodyear Aerospace Corp.,** Akron, Ohio, for expendable *Gemini*-to-*MOL* crew transfer tunnel.

$47,218—**Academy for Interscience Methodology, Museum of Science and Industry,** Chicago, for a study of defense against ballistic missile attack.

$29,700—**TRW/Space Technology Laboratories,** Redondo Beach, Calif., for techniques for advanced isolated transistor structures.

$24,848—**United Nuclear Corp.,** Development Div., White Plains, N.Y., for feasibility and hazard analysis study for an unshielded fast burst reactor proposed to be located at Brooks AFB, Tex.

ARMY

$18,615,000—**Martin Marietta Corp.,** Baltimore, for improved *Pershing* weapon system ground support equipment.

$4,222,780—**Morrison-Knudsen Co.,** Boise, Idaho, and **Norcoast, Inc.,** Seattle, for joint contract for construction work at Amchitka Island for Operation Long Shot underground nuclear test.

$2,272,328—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for industrial engineering services on the *Shillelagh* missile system.

$1,957,000—**Martin Marietta Corp.,** Orlando, Fla., for continued work on *Pershing* missiles.

$795,990—**Smith and Sapp Construction Co.,** Orlando, Fla., for two new supply and equipment buildings for NASA's Moon launch area on Merritt Island.

$500,000—**Raytheon Co.,** Andover, Mass., contract modification for design, deveopment and fabrication of a ballistic missile target system for *Hawk.*

$397,873—**Union Carbide Corp.,** New York City, for 12-month continuation of research on physical and chemical principles affecting high-temperature materials for rocket nozzles.

$184,993—**Akwa-Downey Construction Co.,** Milwaukee, Wis., for two antenna foundations and a boresight tower foundation for the Central Instrumentation Facility at Merritt Island.

$152,155—**International Business Machines Corp.,** Huntsville, Ala., for renewal rental of ADP equipment.

$151,939—**Stanford Research Institute,** Menlo Park, Calif., for support of Project Dazzle reentry physics program.

$91,000—**Akwa-Downey Construction Co.,** Milwaukee, Wis., for pile foundations to support spacecraft work stands in the Manned Spacecraft Operations Building at Merritt Island.

$49,452—**Northrop Corp.,** Anaheim, Calif., for *Hawk* wing assemblies.

$20,783—**The Unitec Corp.,** Timonium, Md., for erecting a 300-ft. radio tower at Merritt Island.

NAVY

$43,754,100—**Bath Iron Works Corp.,** Bath, Maine, to build three missile-firing destroyers for West Germany's navy.

$1,693,330—**Todd Shipyards Corp.,** Brooklyn, N.Y., for instrumentation modification to AF Eastern Test Range Instrumentation Ships, USNS Coastal Crusader and Sword Knot.

$249,245—**Aerojet-General Corp.,** Azusa, Calif., for research and development program for hybrid motors.

$39,600—**Raytheon Co.,** Waltham, Mass., for manufacture of four *Polaris* MK II electronic computers.

$29,623—**Farmers Tool and Supply Corp.,** Denver, for *Sidewinder* wing assemblies.

$26,315—**M. Rosenblatt and Sons, Inc.,** San Francisco, for shipboard missile system study.

$25,000—**Northwestern University,** Aerial Measurement Laboratory, Evanston, Ill., for missile system parameter studies.

NASA

$4,050,508—**Radio Corp. of America,** Astro-Electronics Div., Hightstown, N.J., increase in contract for *TOS* system.

$1,572,000—**Monitor Systems Inc.,** Fort Washington, Pa., to design, construct and install two telemetry data computer interface systems for Kennedy Space Center.

$321,000—**Data Control Systems,** Danbury, Conn., for ground telemetry data reduction facility.

$315,000—**United Nuclear Corp.,** Development Div., White Plains, N.Y., for fabrication, delivery and installation of gamma probe scanning system.

$200,000—**Monsanto Research Corp.,** Boston Laboratories, Everett, Mass., for study of fuel cells using storable rocket propellants.

$100,000—**Ball Brothers Research Corp.,** Boulder, Colo., for pointing controls and telemetry systems.

$97,576—**System Development Corp.,** Santa Monica, Calif., to perform an operations study of the computer complex at Goddard Space Flight Center.

$95,937—**Nuclear Utility Services,** Washington, D.C., for nuclear hazards analysis.

$94,850—**General Electric Co.,** Reentry Systems Div., Philadelphia, for evaluation of micrometeoroid effects on heat shield performance.

$90,000—**TRW/Space Technology Laboratories,** Redondo Beach, Calif., for support of *OGO* experimenters and quick repair services for *OGO-B* subassemblies.

$69,485—**Washington Aluminum Co.,** Baltimore, for design and fabrication of a spacecraft positioner.

$58,440—**Valey Electric Co.,** Freemont, Ohio, for construction, installation and connection of the electrical control system and the rocket nozzle instrumentation for the hydrogen heat transfer facility at Plum Brook Station, Sandusky, Ohio.

$57,317—**Wyle Maddox,** Chincoteague, Va., for construction of antenna foundation, Weather Bureau satellite station, Wallops Station, Va.

$54,660—**Space General Corp.,** El Monte, Calif., for *Aerobee 150/150A* attitude control system services.

$44,552—**Dynamics Research Corp.,** Stoneham, Mass., for theoretical research study and analysis of the *Apollo* range tracking vehicle navigation system.

$41,131—**Atlantic Research Corp.,** Alexandria, Va., for rocket motor and igniter.

$39,875—**Aracon Geophysics,** Concord Mass., for performing an evaluation of meteorological content and application of the *Nimbus 1* HRIR data.

$39,800—**Fairchild Hiller Corp.,** Rockville, Md., for design analysis and fabrication of *OGO-E* experiment container.

$33,500—**Standard Kollsman Industries, Inc.,** Syosset, N.Y., for design of a hand-held space sextant for use in *Gemini* space vehicle.

$31,353—**Consolidated Systems Corp.,** Pomona, Calif., for minitrack command console.

$27,221—**Honeywall, Inc.,** Boston, for design and fabrication of magnetometer sensors single-axis and electronic packages.

$25,704—**Texas Woman's University,** Denton, Tex., for biosatellite project experiment on investigation of bone density changes in various sites of the skeletal anatomy of primates.

$25,000—**Avco Corp.,** Aerospace Structures Div., Nashville, Tenn., for optimization of the *Saturn IB* and *V* mounting and thermal conditioning panels.

North American Aviation, Inc., Autonetics Div., Anaheim, Calif., for a 10-month study on a control system to keep vibrations from adversely affecting the flight of large launch vehicles (amount not disclosed).

INDUSTRY

$34,000,000—**Martin Marietta Corp.,** Martin-Orlando Div., Orlando, Fla., from **Bell Telephone Laboratories,** Whippany, N.J., for continued development work on the *Sprint* anti-missile missile.

$2,300,000—**The Bendix Corp.,** North Hollywood, Calif., from **The Boeing Co.,** Seattle, for modification of emplacement systems for *Minuteman.*

$1,000,000—**United Aircraft Corp.,** Hamilton Standard, Windsor Locks, Conn., from **Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for equipment to check out and insure the reliability of the life-sustaining environmental control system for LEM.

$1,000,000—**Bogue Electric Manufacturing Co.,** Paterson, N.J., from **General Telephone and Electronics Corp.,** Sylvania Electric Products, Inc., New York City, to manufacture an electronically controlled system to supply uninterrupted electric power for underground command posts which regulate the targeting and firing of *Minuteman.*

$25,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., from **Collins Radio Co.,** Dallas, for *Apollo* VHF sets.

Pittsburgh-Des Moines Steel Co., Pittsburgh, from **Lockheed Aircraft Corp.,** Missiles and Space Co., Sunnyvale, Calif., for the fabrication and construction of a man-rated environmental altitude chamber capable of simulating vacuum conditions at 250,000 ft. (amount not disclosed).

ATOMIC ENERGY COMMISSION

$7,500,000—**Computer Sciences Corp., Los Angeles,** five-year contract to provide computer services at the Hanford works neat Richland, Wash.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

RFP C-203274 due May 3, 1965, for research and development to design, fabricate and test a gas-to-liquid compact heat exchanger within 12 months. For proposal request phone AC 216-433-4000, extension 525. Copies will be issued on a first come, first served basis. This procurement is for prototype hardware for use in a space system and only those having a substantial engineering background in the design, fabrication and delivery of high performance heat exchangers for use in aircraft or space vehicles will be considered for award of the contract.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio, 44135

RFP 203279 was issued on March 31, 1965 to Thomson-Ramo-Wooldridge, Inc. for a continuation of a program on a receiver/heat storage unit using solar energy as the heat source and argon gas as the working fluid. Mr. K. E. Werner has been invited by NASA to submit a proposal for subcontracting opportunities by April 19.

National Aeronautics and Space Administration
Headquarters
Washington, D.C.

NASA is negotiating with Spacecraft Inc. for research to determine causes of flight failure and corrective measures to assure success of future flights. For information only; RFP not available.

Mauler Project Office
U.S. Army Missile Command
Redstone Arsenal, Alabama

Those interested in subcontracting opportunities with Canadian Commercial Corp. for tasks to continue the Mauler infrared acquisition program should contact the firm directly. Contract number is DA-20-018-AMC-1354(Z).

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Virginia

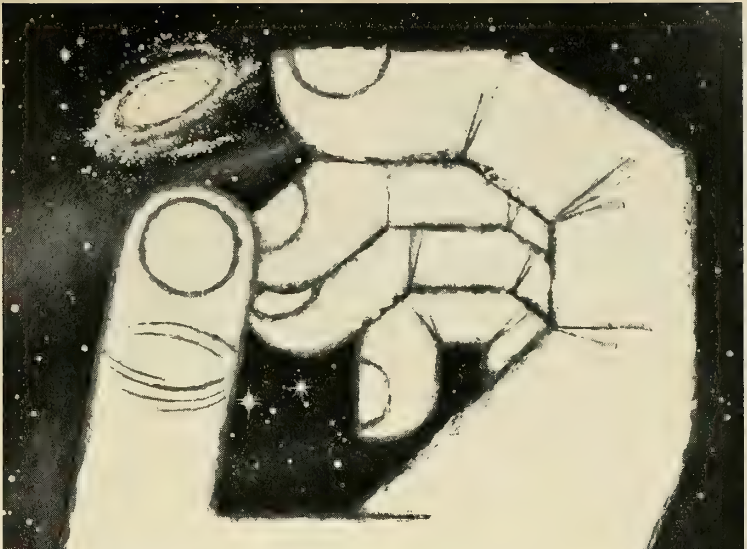
Langley Research Center is negotiating a contract with Allied Research Associates for a photomechanical investigation of thermal and pressure stresses in the Algol solid-propellant rocket motor nozzle. This notice is for information only; RFP not available.

Office of the Executive Director
U.S. Arms Control and Disarmament Agency
21st and Virginia Avenue, N.W.
Washington, D.C. 20451

RFP 65-5 due on April 29, 1965, for study of the feasibility of verifying a prohibition of field testing of chemical and biologcal weapons.

Directorate of R&D Procurement
Systems Engineering Group
Research and Technology Division
Wright-Patterson AFB, Ohio 45433

Research is required to develop an instrument that will solve research problems relating to analysis of the resolving power capabilities of ultra-violet photosensitive materials in the wave lengths region of 300 to 4500 Angstroms. Requests must be in by April 20, 1965.



How high is your goal?

Ours are out of sight — in the labyrinth of space. But your opportunities are a tangible reality, here and now, at North American's Space and Information Systems Division.

PROPULSION SYSTEM TEST

Will assist in conducting propulsion tests, analyzing test data and the preparation of pre-installation and post installation checkout procedures. Will also be involved in the definition of test requirements, integrated systems, and pre-launch verification tests. Qualified candidates will have testing experience in liquid rocket propulsion systems. A BS or MS in ME, AE, or CHEM. E is required.

ENVIRONMENTAL CONTROL

Develop operational test procedures for the checkout of the environmental control system. Perform and direct malfunction analysis and prepare development test plans. This position requires a BSME with applicable experience as well as familiarity with Cryogenics.

STABILIZATION AND CONTROL

Will develop operational test procedures for spacecraft checkout of stabilization and control systems which utilize reaction jets. Must be able to develop electronics checkout systems in support of this effort. A BSEE and three years experience in stabilization and control checkout required.

The above descriptions are examples of the many fine test positions that are presently available at our Downey, California location, and our Mississippi Test Facility.

To explore these or other professional engineering opportunities please submit your resume to:

MR. B. D. MUSIK
ENGINEERING AND SCIENTIFIC EMPLOYMENT
12214 LAKEWOOD BLVD.
DOWNEY, CALIFORNIA

All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

North American Aviation
Space & Information Systems Division

Jet DELTA for coast-to-coast orbits
SAN FRANCISCO
LOS ANGELES
SAN DIEGO
DALLAS
HOUSTON
Huntsville
NEW ORLEANS
ATLANTA
ORLANDO Cape Kennedy
MIAMI

The only thru Jets between California and Atlanta-Orlando/Cape Kennedy

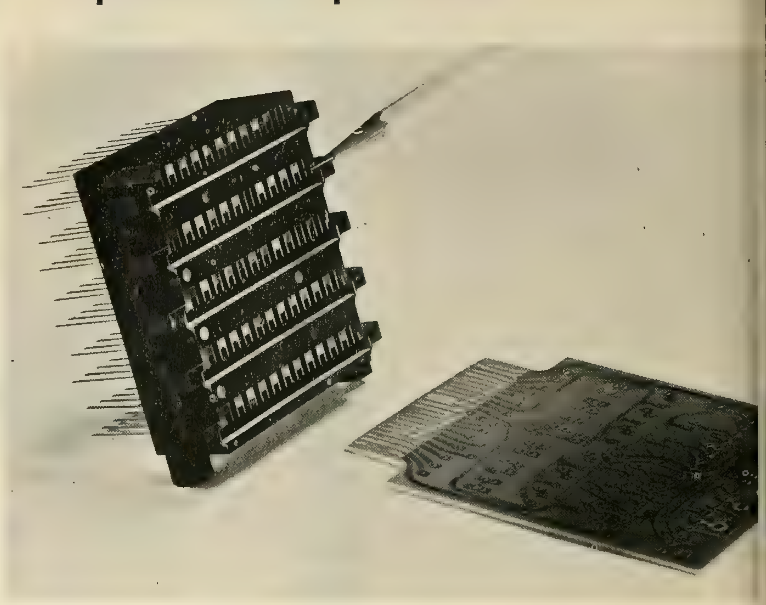
- 15 Jet flights daily between Dallas and California
- Round trip tourist fare, 7-22 days, Orlando-Los Angeles $220; Orlando-San Francisco only $240. *Add tax to airfares*

Call Delta or see your Travel Agent

DELTA

the air line with the BIG JETS

products and processes



New Product of the Week: Circuit Board Receptacles

A line of printed circuit board receptacles using contacts with precious metal tips at the mating surface has been developed by Amphenol-Borg Electronics Corp.

The Series 231, called PMTips, is designed for use where numerous printed circuit board interconnections are needed. The connectors are stacked side-by-side in frames and interwired using hand-operated or automatic Termi-Point or Wire-Wrap terminals.

The units are available in three sizes: the 231-1 with 180 contacts on 0.125-in. centers (10 rows of 18 contacts); 231-2 with 176 contacts on 0.125-in. centers (8 rows of 22 contacts); and 231-3 with 115 contacts on 0.1-in. centers (5 rows of 23 contacts). The units are rated at 500v ac RMS at 7.5 amp. Voltage breakdown rating is 1,800v ac RMS.

All contact members are phosphor bronze with a reflowed solder finish. Contact buttons are 75% gold, 25% silver alloy.

Circle No. 151 on Subscriber Service Card

Decay Rate Meter

A decay rate meter for determination of reverberation time of acoustical and mechanical systems is being marketed by Spencer-Kennedy Laboratories, Inc.

The Model 507 has application in measurement of noise control and determination of structural response and fatigue in mechanical systems. It employs an oscilloscope output to display detail in the reverberation pattern that cannot be detected by graphic devices. Response time is 100 times that of graphic level recorders, the firm says. Highly damped structures and damping materials can be studied at frequencies up to 10,000 cps. At 1,000 cps, loss tangents as high as 0.4 may be evaluated.

Frequency range is 10 cps to 50 kc. Reverberation time range is 0.005 to 10 seconds with calibration accuracy better than ±10%. Log amplifier range is 30 db ±1 db and 50 db ±3 db with response time of 10^6 db/sec. Repetition rate is variable between 0.2 and 20/sec.

Circle No. 152 on Subscriber Service Card

CRT Gun Assembly

A six-in-one gun assembly, part of the SC-3814 cathode ray tube developed for use in airborne countermeasures equipment, has been announced by Sylvania Electric Products, Inc.

The use of multi-guns makes possible simultaneous displays on one 10 x 12-in. rectangular face plate, the company says. The mount is approximately 7 in. high. The 21-in.-long CRT has an encapsulated Mu metal shield. Color-coded leads are brought out through he encapsulation. The component has 4-kv anode voltage and is available in P-7 phosphor or other phosphors as required. Deflection factors are ID2 for 30 to 100v and 3D4 for 38 to 50v dc per inch.

Circle No. 153 on Subscriber Service Card

Miniature Power Supply

An encapsulated, all-silicon power supply, the NPS-30, is being marketed by Nexus Research Laboratory, Inc.

The unit is a reference grade regulator designed to supply power to a few amplifiers in small analog systems. It measures 2.7 x 1.5 x 0.75 in. and weighs 4.4 oz. Input is ± 25 to ± 40v ac or dc, 50 cps up. Output is ± 12 to ± 18v at up to 35 ma. Regulation is 0.01%.

Circle No. 154 on Subscriber Service Card

Silicon Counter

An all-silicon high-speed counter with in-line display is being marketed by Janus Control Corp.

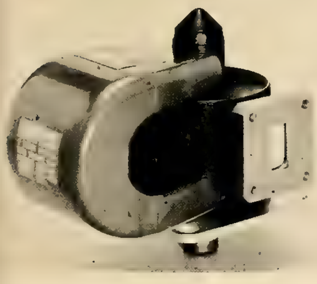
The Model B-100-50 counts at rates from 0 to 50 mc and displays the decimal count as accumulated. "Output carry" and "output BCD levels" are provided. Since the circuit uses a common, rather than a ground, the drive signal may have an arbitrary reference level that matches the requirements of a variety of standard and non-standard logic control levels.

The building block module measures 3 x 5 x 1 in. Operating temperature range is 0 to 60°C.

Circle No. 155 on Subscriber Service Card

Pulse Magnetron

A metal-ceramic coaxial pulse magnetron, applicable for airborne or lightweight radar systems such as fire control or navigation systems, has been introduced by Litton Industries' Electron Tube Div.



The Model L-3958, manufacturers say, is the only 10-kw, Ku-band coaxial magnetron in production. It operates at a fixed frequency of 15,500 ± 85 mc and has 40% efficiency.

Circle No. 156 on Subscriber Service Card

ELECTRONIC ENGINEERS

IT TAKES GUTS....

and technical savvy... and the ability to be boss...to be a Ship Operations Manager with Pan Am's Guided Missiles Range Division.

With a launch in progress, be it missile, manned space craft, satellite or space probe, he repeatedly makes important, split-second decisions with the chips down. A multi-million dollar mission may depend on his know-how.

These are the men who manage the instrumentation complex on each tracking ship along the 10,000 mile length of the Eastern Test Range. They take full responsibility for directing the real-time monitoring of vehicle performance in flight... using pulse and CW radar, telemetry, optics, infrared, timing, command/control, data encoding and transmission equipment of the latest design. They perform in-flight trajectory measurements, utilizing digital computers and inertial navigation systems. Among major programs to be supported in the future are GEMINI, MOL/GEMINI B, and APOLLO.

If you have a strong technical background in these many areas of electronics...if you have engineering management ability and can make the right decision under pressure...if you want broad exposure to the whole world of range technology, a springboard to even more important positions at the Cape, write in confidence to Manager, Professional Employment, Dept. 56 D-4.

PAN AM
GUIDED MISSILES
RANGE DIVISION
PAN AMERICAN WORLD AIRWAYS, INC.
P. O. BOX 4465, PATRICK AIR FORCE BASE, FLORIDA

Circle No. 9 on Subscriber Service Card

Crystal Grower

A crystal growing furnace, said to have double the capacity of earlier models, has been announced by National Research Corp., a subsidiary of Norton Co.

The Model 2805 is used to "grow" crystals of silicon, germanium and other materials for use in transistors and diodes and as base material for microminiature circuits. Capacity of the device is about 550 cu. cm., sufficient to handle a 1,050-gram silicon charge. It operates under vacuum or an inert gas and will routinely "pull" silicon and other materials up to 2 in. in diameter.

The unit features a decreased down time and twin viewing ports. It has a saturable core reactor power supply for continuous uninterrupted control of the resistance heater. Crucible temperature control is guaranteed to ±0.5°C and routinely achieves ±0.2°C. Temperature range is 600° to 1,600°C.

Circle No. 157 on Subscriber Service Card

TV Camera

Du Mont Laboratories of Fairchild Camera and Instrument Corp. is marketing a closed-circuit television camera system, designed to incorporate high-resolution with minimum size and weight.

The Type TCS-950 produces in excess of 1,000-line center horizontal resolution at all scan rates and vertical resolution of 700 lines using a 1,029-line per frame format. Typical scan rate formats available are 525, 625, 875, 945 and 1,029 lines per frame. At 525 lines/frame, video signals produced are in conformance with EIA standard RS-170.

The camera head measures 2.75 in. in diameter and 13 in. long. Weight is 5 lbs. Camera control unit dimensions are 3.75 x 6.5 x 14.25 in. Weight is 16 lbs. The head may be remoted to distances up to 1,000 ft. from the control unit.

Circle No. 158 on Subscriber Service Card

Carbon/Hydrogen Analyzer

American Instrument Co., Inc., is marketing a carbon and hydrogen analyzer that requires a single weighing per analysis.

The unit can determine both elements within 90 seconds after introduction of the sample. A record of the analysis is provided in a recorded readout by means of which signal amplitudes are related to carbon and hydrogen percentages. Precision and accuracy are within ±0.3%.

During operation, a sample, weighing from 0.2 to 1 mg, is burned over copper oxide at 1,000°C in pure oxygen. All combustion products are retained except carbon dioxide, the concentration of which is measured as it passes through a thermistor detector. Water is then quantitatively converted to hydrogen, which is measured by the same detector.

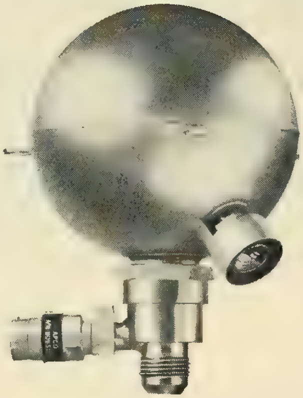
Circle No. 159 on Subscriber Service Card

Centrifugal Pump

A three-stage Turbocraft centrifugal pump has been introduced by Cosmodyne Corp. The pump is designed for medium flow (50 to 300 gpm), medium pressure (200 to 500 psi), transfer or recycling of cryogenic liquids such as oxygen, nitrogen, ethylene or methane, or for process plant pumping of fluids up to 300°F.

The pump's hydraulic design results in a flat performance curve, permitting the operator to use the pump for a variety of pressures and flows at comparatively constant efficiencies, the firm says. Actual performance tests have shown the efficiency to vary between 45 and 58% over a flow range of 50 to 170 gpm. A specially designed impeller permits operation of the pump at an NPSH of less than 2 ft. and at reduced flow, at zero NPSH.

Circle No. 160 on Subscriber Service Card



FIRE PROTECTION...by the bottle!

This light weight stainless steel fire extinguisher container is one of many APCO fire bottles made in a range of sizes, shapes and fluid media for aircraft and auxiliary power equipment. All these units are giving dependable service on both military and commercial aircraft produced by Boeing, Lockheed, Convair, Northrop and others.

Operation is unique. The unit is instantly activated by a remote electrical signal which in turn causes an explosive squib-actuated knife to shear the diaphragm in such a way that **full opening is achieved.** Thus, there is no restriction of flow, and no downstream debris to interfere with nozzles or spray rings. Prior to shearing, the diaphragm provides an **absolutely leak-proof seal.**

APCO fire bottles are rechargeable without use of special tools... incorporate a rugged, gearless pressure gauge...can be supplied with single or dual heads...in alloy steel, stainless steel or aluminum alloy ...in sizes from 72 in^3 to 1050 in^3...and with all related valving. They are fully applicable to military specifications, and conform to ICC Specifications. APCO will refurbish or retrofit systems which are obsolete, past service date or fatigue life. Such replacements are interchangeable with original equipment.

APCO **capability** in component design, development and manufacturing is assurance of APCO **reliability** in aircraft and missile service. **For further information, or for assistance on your specific requirements, write APCO today.**

APCO ACCESSORY PRODUCTS CO.
FLUID CONTROL • SYSTEMS • COMPONENTS
A textron CO.
616 West Whittier Boulevard • Whittier, California

Circle No. 10 on Subscriber Service Card

NASA'S NEW

ELECTRONICS RESEARCH CENTER

A SPECIAL REPORT...

...to be published in MISSILES AND ROCKETS May 31, 1965 issue. The new center, although just entering the construction phase, has already issued RFP's to industry for electronics research contracts. The center which will eventually direct 50% of NASA's electronics research, has a FY '66 budget which already has reached $22 million, and by 1969 should reach $100 million.

More important, the Electronics Research Center will be in the forefront of NASA's drive to achieve the state-of-the-art advances in electronic systems and components required to carry out the sophisticated space missions planned in the late sixties and through the next two decades.

This report will provide in-depth analyses of Electronics Research Center's plans and programs, procurement policies, responsibility in electronic research and the construction schedule, costs and equipment for the individual laboratories.

For companies marketing to NASA, this report offers a unique opportunity to reach the heart of the buying influences. Plan now to capitalize on this outstanding advertising opportunity.

Bonus Circulation: This issue of MISSILES AND ROCKETS will be delivered to every engineer, every designer, every scientist, and every management man at the Electronics Research Center. Copies will be made available to other Electronic Centers of NASA.

PUBLISHED: MAY 31 **ADVERTISING CLOSES: MAY 17**

missiles and rockets

the weekly of advanced technology

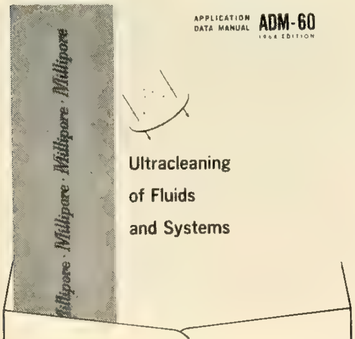
THE TRUE SCIENTIST

The true scientist, the creative engineer, has a light in his eye that money can't buy. A man's real warmth for his job, his real measure of attainment, does not begin and end with his paycheck—important though that is.

To find himself in the right emotional and creative climate; to rub elbows with acknowledged masters in his field; to contribute to America's future — these are the rewards which impel men of outstanding talent to come to Lockheed Missiles & Space Company.

We invite you to join their proud company. Write Dept. 530, P.O. G504, Sunnyvale, California. An equal opportunity employer.

LOCKHEED
MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION


APPLICATION DATA MANUAL ADM-60
1964 EDITION
Ultracleaning of Fluids and Systems
Millipore · Millipore · Millipore · Millipore

Worth writing for

ADM-60, Ultracleaning of Fluids and Systems illustrates the design of both open-end and re-circulating systems for cleaning hydraulic fluids with Millipore filters in test stands, fill-flush-and bleed stands and in airborne vehicles. Also covers ultrasonic and solvent-type cleaning systems. To receive a free copy of this 30-page manual, write to

Millipore®
FILTER CORPORATION
200 Ashby Road, Bedford, Mass.

(Millipore® filters are cellulose plastic porous membranes made in twelve pore-size grades from 8 microns down to 10 millimicrons. In microfiltration or analysis, all matter larger than the filter pore size is screened from fluids and retained on the filter surface)

names in the news

RECTOR

TRAVIS

WALLACE

GETTY

Robert W. Rector: Elected vice president-plans and programs of Informatics Inc. He will be replacing **F. V. Wagner** who has been promoted to vice president-western operations.

Dr. Irven Travis: Appointed vice president, technological development, of Burroughs Corp. He was formerly vice president and group executive of Burroughs Defense & Space Group.

Robert E. Wallace: Elected as a vice president of Auerbach Corp. He is also director of marketing and director of the information products group.

Hugh R. Getty: Named manager of advanced communications at Martin Co's Orlando Div. He was formerly manager of future programs at Philco Corp.

Dr. William F. Gilliam: Named manager of technical information at General Electric's Silicone Products Dept. He is a member of GE's original scientific group in the development of silicones.

Robert E. Forrester: Named vice president-sales and engineering of the Aero-Corry Div. of Aero-Flow Dynamics, Inc. He will be responsible for the engineering and marketing efforts of the division.

Page Noll, Jr.: Appointed director of the newly-established materiel organization of the Aeronutronic Div. of Philco Corp. **Arthur C. Haines** was named director of operations and acting manager of the Lawndale Army Missile Plant. Both appointments are tied to the forthcoming mass production of the U.S. Army *Shillelagh* missile.

Robert C. Becherer: Elected chairman of the board of Link-Belt Co. He was formerly president of the company and will be succeeded in that post by **Harlan B. Collins.**

Dr. E. C. Johnson: Appointed assistant general manager of the Bendix Research Laboratories division of Bendix Corp.

Gifford K. Johnson: Named president of the Graduate Research Center of the South West in Dallas, Tex. He was formerly president of Ling-Temco-Vought Corp. **Dr. Lloyd Berkner,** former president of the Center, has become chairman of the executive committee and will continue to head the scientific programs as director of the Southwest Center for Advanced Studies.

John Ma: Rejoined Oak Manufacturing Co., a division of Oak Electro/Netics Corp., in the newly created position of assistant to the vice president of engineering.

C. R. Braun: Appointed executive vice president of Nuclear Fuel Services, Inc., a majority owned subsidiary of W. R. Grace & Co.

Wilbur E. Dunkel: Elected to the board of directors of Tenney Engineering, Inc. He is vice president of the First National State Bank of New Jersey.

Gerald A. Louie: Promoted to head of materiel activities for the Electronics Division-Portland of Electronic Specialty Co.

Bruce R. Carlson: Elected treasurer of Sprague Electric Co., replacing **Robert C. Sprague,** who continues as chairman of the board and chief executive officer. He was also elected a director of the company.

Col. Harry F. Bunze, USAF (Ret.): Joined Lockheed Propulsion Co. as advanced projects manager. He was director of advanced conceptual planning for ballistic systems with the Air Force.

James Sewell: Named aerospace field sales manager by U.S. Polymeric. This is a new position created to provide field support for sales engineers and improve servicing of accounts.

Robert P. Kenney: Appointed to the newly-created position of vice president-international of B. F. Goodrich Chemical Co.

Dr. Nicholas Yaru: Named a vice president of Hughes Aircraft Co. He will continue as manager of the company's Hughes-Fullerton radar division.

Frank E. Hoffman: Joined Planning Research Corp. as a senior associate in the Systems Engineering Div. He will be engaged in studies in the areas of system design and analysis for aircraft and space vehicles.

Russell W. Harter: Joined Washington Technological Associates, Inc. as senior project engineer. He was formerly chief engineer of the desomatic division of Atlantic Research.

let us move with you!

Six Weeks Is Required To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, if possible, **the address label from your last issue** . . include your postal ZIP number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Paris, France—11 Rue Condorcet; TRU 15-39

—when and where—

APRIL

23rd Annual Meeting of the National AeroSpace Services Assn., Washington Hilton, Washington, D.C. April 12-13.

Practical Aspects of Dynamic Programming, sponsored by the Detroit Research Co., Detroit, April 12-13.

Conference on Atomic Spectra and Radiation Processes, Oxford, England, April 12-14.

National Aeronautic Meeting and Production Forum, sponsored by the Society of Automotive Engineers, Inc., Sheraton-Park Hotel, Washington, D.C., April 12-16.

Pricing and Negotiating Prime and Sub-Contracts in the Defense and Aerospace Industries, sponsored by Contract Management Institute, The Columbia University Club, New York City, April 12-16.

Dynamics of Defense Marketing, sponsored by the NDEI, Los Angeles, April 13-15.

15th Annual National Telemetering Conference, sponsored by the IEEE, ISA and AIAA, Shamrock-Hilton Hotel, Houston, April 13-15.

1965 Annual Region VI Conference of the IEEE, Las Vegas, Nev., April 13-16.

Advanced Planning Briefings for Industry, sponsored by DOD and NSIA, Marriott Motor Hotel, Dallas, April 14-15.

1965 Electronics & Instrumentation Conference and Exhibit, sponsored by ISA, Cincinnati Gardens, Cincinnati, Ohio, April 14-15.

New Horizons in Computation. sponsored by the Association for Computing Machinery, Marriott Twin Bridges Motor Hotel, Arlington, Va., April 15.

International Conference on Programming and Control, sponsored by the Air Force Office of Scientific Research and the University of California, U.S. Air Force Academy, Colorado Springs, Colo., April 15-16.

Symposium on Human Physiological and Performance Determinants of Manned Space Systems Design, sponsored by the American Astronautical Society and the Human Factors Society, California State College, San Fernando, Calif., April 15-16.

International Conference on the Mechanics, Physics and Chemistry of Solid Propellants, sponsored by the Office of Naval Research and Purdue University, Purdue University, Lafayette, Ind., April 19-21.

Third National Biomedical Sciences Symposium, sponsored by the Instrument Society of America, Statler Hilton Hotel, Dallas, April 19-21.

International Conference on Modern Trends in Activation Analysis, sponsored by the International Atomic Energy Agency, U.S. Atomic Energy Commission and Texas A&M University, Activation Analysis Research Lab., College Station, Tex., April 19-22.

Advertisers' Index

APCO DIV. OF TEXTRON, INC. 42
Agency—Swan/Mealer, Inc.

AUTONETICS, A DIV. OF NORTH AMERICAN AVIATION, INC. 32
Agency—Batten, Barton, Durstine & Osborn, Inc.

BOEING CO., THE 5
Agency—Campbell-Ewald Co.

CONSOLIDATED ELECTRODYNAMICS CORP. 34
Agency—Hixson & Jorgensen, Inc.

DELTA AIR LINES, INC. 40
Agency—Burke Dowling Adams, Inc.

DOUGLAS AIRCRAFT CO., INC., MISSILE & SPACE SYSTEMS DIV. 2
Agency—J. Walter Thompson Co.

ELECTRO-OPTICAL SYSTEMS SUB. OF XEROX CO. 18
Agency—Scott, Rifkin & Wilson, Inc.

EX-CELL-O CORP., FLIGHT & SPACE DIV. 26
Agency—LaRue & Cleveland, Inc

GENERAL ELECTRIC CO., APOLLO SUPPORT DEPT. 36
Agency—Deutsch & Shea, Inc

GENERAL PRECISION, INC. 8, 9
Agency—Gaynor & Ducas, Inc.

HEXCEL PRODUCTS, INC. 4
Agency—Lennen & Newell

HUGHES AIRCRAFT CO. 31
Agency—Foote, Cone & Belding

HYDRO-AIRE, DIV. OF CRANE CO. ... 11
Agency—Scott, Rifkin & Wilson, Inc.

LOCKHEED AIRCRAFT CORP 24, 25
Agency—Foote, Cone & Belding

LOCKHEED MISSILES & SPACE CO. 44
Agency—Hal Stebbins, Inc.

MILLIPORE FILTER CORP. 44
Agency—Culver Adv. Inc.

PAN AMERICAN WORLD AIRWAYS, INC., GUIDED MISSILES RANGE DIV. 41
Agency—Deutsch & Shea, Inc.

SPACE & INFORMATION SYSTEMS DIV. OF NORTH AMERICAN AVIATION, INC. 39
Agency—Batten, Barton, Durstine & Osborn, Inc.

SPERRY GYROSCOPE CO. 48
Agency—Reach, McClinton & Co

UNIVAC DEFENSE SYSTEMS DIV., SPERRY RAND CORP. 47

VALCOR ENGINEERING CORP. 6
Agency—Keyes, Martin & Co.

editorial . . .

Moon Struck

IT IS TIME TO APPLY some common sense to U.S. plans for lunar exploration before further millions, and perhaps billions, of dollars are wasted. *Ranger,* which now must be rated as a spectacular success, nevertheless has failed to produce any data of use to the *Apollo* program.

This should in no way detract from the fine performance of Jet Propulsion Laboratory's *Ranger* project team under the direction of H. M. (Bud) Schurmeier. The fault lies not with JPL but with the National Aeronautics and Space Administration in the drawing up of mission requirements.

Dr. Homer E. Newell, NASA associate administrator, told Congress last year: "*Ranger* will play an important role in the support of Project *Apollo.*"

The *Ranger* program now is completed. It is fair to ask what we have learned that is useful to *Apollo.*

Not a single change has been made in any part of the *Apollo* system or in the program's operational plan as a result of the *Ranger* findings. None is contemplated. The reason for this is simple. The Block III *Rangers* were incapable of producing any such data.

NASA takes a different view, rejecting the criteria of change as a measure of *Ranger*'s usefulness to *Apollo.* The space agency says information from *Ranger* validated *Apollo's* hardware design and mission analysis.

Let us ask then just what this validation consisted of. It is clear from studying the conclusions of the photo evaluation team, as reported this week and last week in MISSILES AND ROCKETS, that the only real point of agreement among the lunar scientists is that the Moon's surface is smooth enough for an *Apollo* landing. Was there ever any question of that? Does NASA seriously suggest that the President, Congress and the American people embarked on a $20-billion manned lunar landing program, a program on which billions already have been spent, while still confronted with the unanswered question of whether the Moon's surface was smooth enough to land on? Poppycock!

In further justification of the *Ranger* program, NASA points out that it has provided valuable data to scientists and astronomers which were not available through Earth-based telescopes. This is true.

But all of this valuable scientific data will be completely outdated by information from the *Surveyor, Lunar Orbiter* and *Apollo* programs. If even better data were not to be obtained soon by these projects, then the expenditure of $263 million on the *Ranger* program might have been justified. Under the circumstances, the money was wasted.

We have pointed this out before (M/R, March 1, p. 46). Our purpose in bringing it up again is to suggest that we may be following the same trail of waste and duplication of goals in the remainder of the funded U.S. lunar exploratory program.

Surveyor is next on the schedule. When *Ranger* and *Surveyor* initially were funded, they were to be operational well ahead of design freeze in the *Apollo* project. *Ranger* slipped three years. *Surveyor* already has slipped three years, including slippage of a year in the last twelve months and a new cost rise of $140 million to a total of $750 million. Its first operational flight now is set for early 1967. Even the Lunar Excursion Module design has been frozen.

The first operational *Surveyor* flight is so close on the heels of the *Apollo* schedule that it is difficult to see how it can be very useful to the manned lunar project. Its report on lunar-surface bearing strengths and the presence and depth of any dust layer may be of some value. But its complexity won't stop there. It will squint and bore and analyze and do all sorts of interesting things.

Meanwhile, at about the same time, *Lunar Orbiter* will be making its sweeping photographic passes around the Moon to relay thousands of close-up photographs of the lunar surface.

NOW, ALL THIS ACTIVITY may turn up some very useful data. There would be no question of the value to science if there were no *Apollo* program and there might even be no question of its value to *Apollo* if men were going to the Moon by direct ascent.

But there is an *Apollo* and it is going to engage in manned lunar orbit flights. There will be experiments ejected from the capsule to test the lunar surface, and astronauts will be taking a close-up first-hand look. You can bet your hat that whatever previous decisions have been made about an *Apollo* landing spot, the final decision about the site will be made at that time.

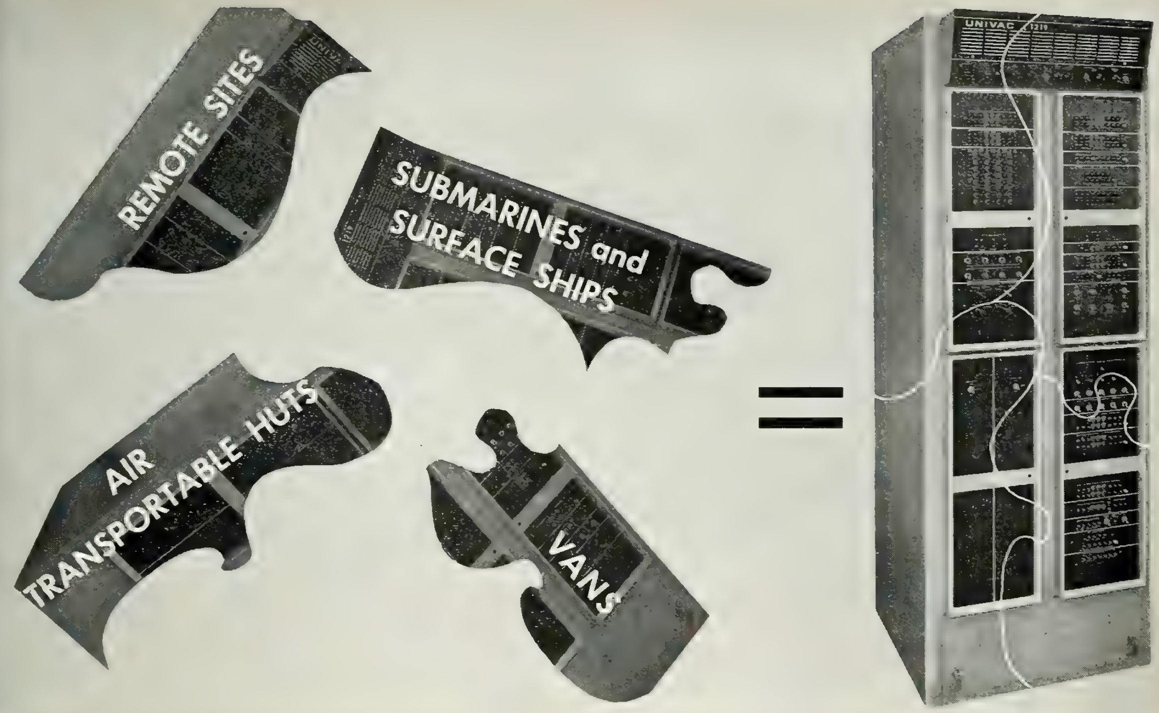
The case for *Surveyor* and *Lunar Orbiter* as supports for the *Apollo* program thus is not a very strong one. Since we are spending over a billion dollars on these two projects, it might be well to ask what else they are to do.

Dr. Newell sees them as part of what he calls the "total program for exploring the Moon." His light regard for the part man will play is seen in the following statement to Congress: "You will have a lunar landing. That lunar landing will involve a few hours of stay on the Moon, a look that the astronauts can make, a few collections of samples, maybe some simple tests, and maybe the emplacement by the astronauts of monitors to be left on the lunar surface."

After their departure, Dr. Newell sees the instruments carrying on. *Lunar Orbiter* wheels overhead. *Surveyor* explores areas on the Moon which man would have difficulty in reaching. It carries what Dr. Newell calls "a small non-complicated roving vehicle"—costing $30 million—to extend *Surveyor's* capability.

We suggest that if anyone proposed exploring the Antarctic in such a manner he would be clapped in the pokey as a nut. Man is going to the Moon and he is going to explore it. Expenditure of billions of dollars on instruments remotely controlled from Earth to do the same job is folly.

William J. Coughlin



WHICH PIECE OF THE PUZZLE IS YOURS?

The UNIVAC® 1219 makes everything fall into place. Compatible with our 1218 but faster and having greater capacity, the 1219 takes up no larger space. Reliable and Rugged, it is designed for installation aboard ships, over-the-road trailers, air transported "huts," command centers or submarines.

. . . Or most any other application you might think of.

Check your own spec sheet requirements with those found in the 1219:

- **REAL TIME**
- GENERAL-PURPOSE
- DESIGNED TO MIL-E-16400
- 18-BIT WORD LENGTH (DOUBLE WORD CAPABILITY)
- MAIN MEMORY—8K TO 65K WORDS; 2 MICROSECOND CYCLE TIME
- CONTROL MEMORY—128 WORDS; 500 NANOSECOND CYCLE TIME
- OPERATING SPEEDS—*14* MICROSECOND MULTIPLY AND DIVIDE
- EIGHT INDEX REGISTERS
- INPUT/OUTPUT 4 TO 16 BUFFERED CHANNELS; UP TO 500 KC TRANSFER RATE
- 102 INSTRUCTION REPERTOIRE; SINGLE ADDRESS
- 29 UNIQUE INTERRUPTS
- 32-WORD PERMANENT MEMORY
- SIZE: 72″x 26¼″ x 30½″
- COMPATIBLE WITH ALL **UNIVAC** MILITARY SYSTEMS
- SOFTWARE—ASSEMBLERS; SERVICE LIBRARY; SUBROUTINE LIBRARY; *FORTRAN*
- STANDARD PERIPHERALS

ANOTHER BIT OF WIZARDY FROM

UNIVAC®

UNIVAC **Defense Systems Division • Sperry Rand Corporation**

Circle No. 13 on Subscriber Service Card

Gravity or Zero Gravity. Under state-of-the-art technology it's feasible to provide effective control subsystems for orbiting vehicles, which spin to produce gravity. Rigidly joined or cable-connected modules can be controlled by present techniques. Sperry has recently evaluated control methods to establish this. □ Zero gravity controls? Sperry has made intensive in-house studies of control needs for vehicles ranging from those with artificial gravity capability to those designed for weightless operation, with minimum control requirements ... for scientific experiments ... and for military missions, from reaction jet to hybrid systems using momentum-exchange concepts. Leader in aerospace control and stabilization, Sperry offers reliable performance for these challenges in space. **GENERAL OFFICES, Great Neck, N. Y.**

SPERRY
DIVISIONS OF
SPERRY RAND
CORPORATION

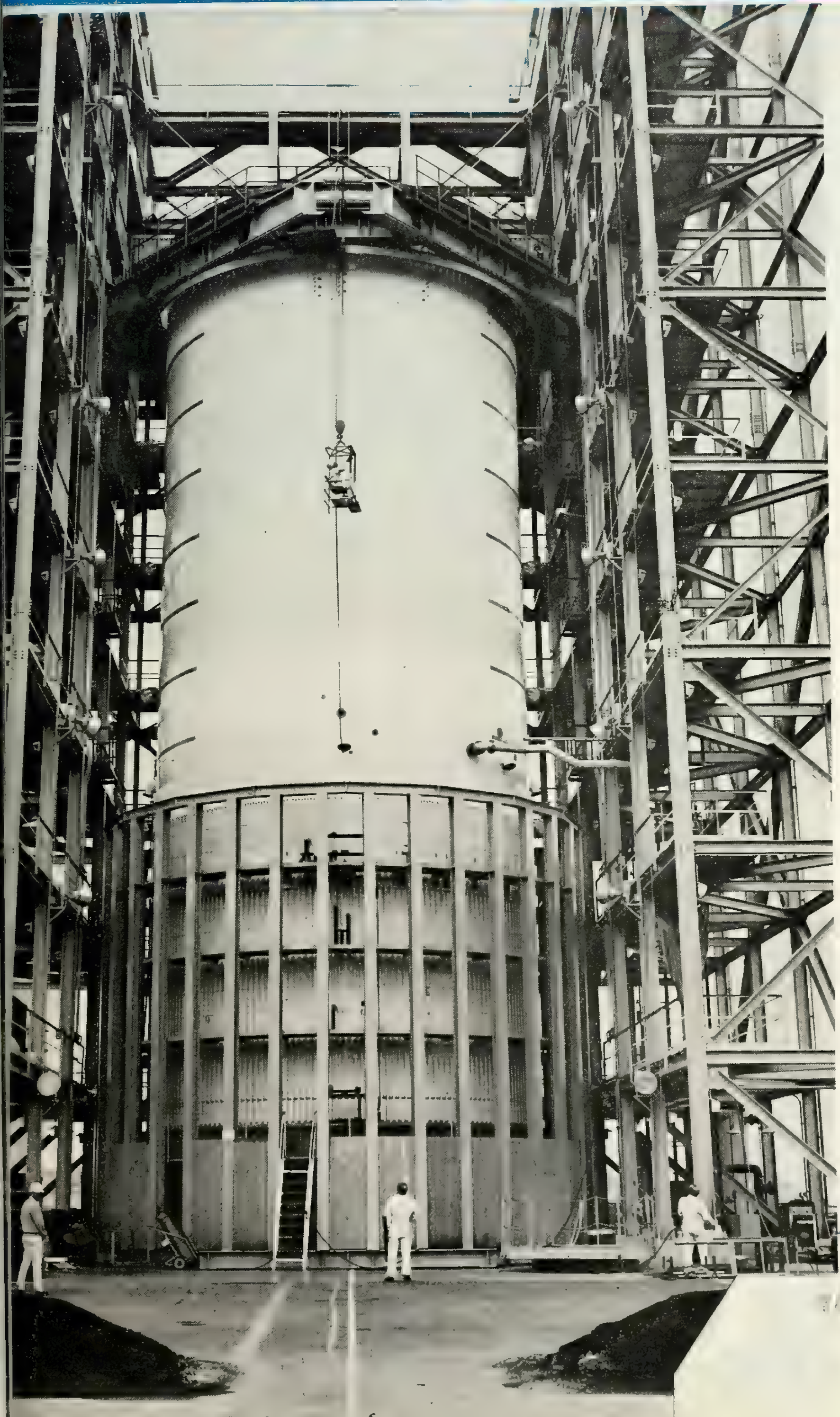
Circle No. 12 on Subscriber Service Card

APRIL 19, 1965

missiles and rockets

HE WEEKLY OF ADVANCED TECHNOLOGY

APR
HOUSTON PUBLIC
LIBRARY
Houston, Texas



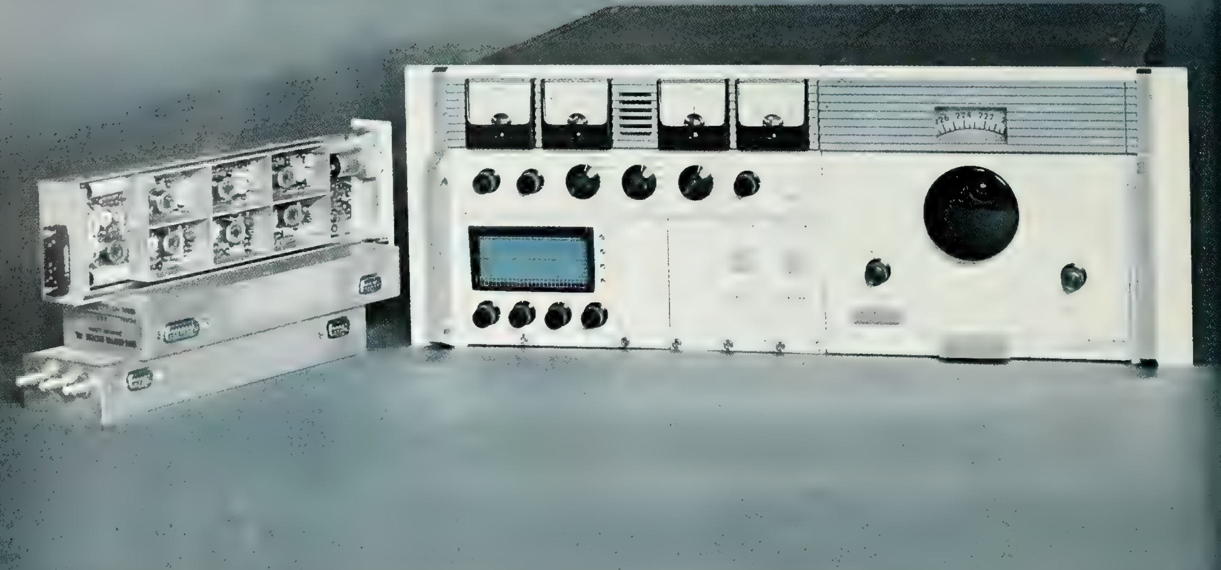
DOD Okays Two Pre-MOL Flight Tests

MSFC To Run Saturn/Centaur

Navy Develops Solids Monitor

New Product Of Year Chosen

S-II Stage of Saturn V In NAA Static Test Facility



New all-solid-state TELCOM receiver covers 100-6000 mc range for Telemetry and Space Communications. Modern etched circuit modules throughout. Front panel plug-ins include IF Filters, Spectrum Display, Predetection Converter, and other modules.

DEMONSTRABLY SUPERIOR

Telemetry Receiver

DCS's new TELCOM receiver in comparative tests demonstrates performance superiority in many important respects including:

Selectivity Distortion Noise Performance Spurious Rejection RFI Characteristics Modular Flexibility

TELCOM is a fundamentally new receiver design—a considerable departure from conventional design practices. Section by section, stage by stage, refinement, innovation and sound engineering practices have been applied to eliminate the many inadequacies of present-day receivers.

TELCOM is a true advancement in receiver technology—providing significant improvement in almost every important performance characteristic:

100% solid state . . . 100 to 6000 mc range . . . High RF selectivity . . . Low input VSWR . . . Meets *all* RFI requirements of MIL-I-26600 . . . Low noise figure . . . Improved large-signal quieting . . . All spurious (not just image) down 60 db . . . Plug-in linear phase IF filters . . . Remote IF filter selection . . . No AGC detuning . . . Reduced IM and harmonic distortion . . . Mean-of-peaks AFC prevents base line shifting . . . Ultra-linear AM and FM detection . . . Stable direct-coupled video amplifier . . . Accurate tuning indicators . . . Versatile front panel plug-ins, including logarithmic spectrum display unit, band-switching predetection converter, IF filters, and others . . . True modularity — interchangeability without adjustment or calibration . . . Precision extruded modules . . . Rugged chassis and module construction.

Try it yourself. Compare more than specifications — compare performance. Find out how much better your data can be with a TELCOM Receiver. Your local DCS representative will be happy to assist you in arranging a demonstration or evaluation.

DATA-CONTROL SYSTEMS INC. *East Liberty Street Danbury, Connecticut 203-743-9241*

ASHINGTON, D.C. 1225 19th Street 202-296-1640
TER PARK, FLA. 116B Park Avenue 305-644-5654
VILLE, ALA. 2109 W. Clinton Ave. 205-536-4907
albott Tower 513-224-9735
100 Travis 713-227-5410
ALBUQUERQUE First Nat. Bank Bldg. E 505-265-8033
LOS ANGELES 5316 W. Imperial Highway 213-678-7191
SANTA CLARA, CALIF. 501 Washington St. 408-241-6820
MUNICH (Technitron) Sonnenstrasse 14 55-78-32
COPENHAGEN (Techni.) 24 Klosterstraede Palae 2632
PARIS (Techni.) 55 Rue Pierre Charron Elysees 30-58
AMSTELVEEN (Technitron) Rottumerstraat 15 8533
ROME (Lampel) Via XX Settembre 27B 47.48.91
STOCKHOLM K (Telare) Industrigatan 4 5433.17
FELTHAM, ENGLAND (S.E. Labs) N. Feltham Fel 5876

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 16 April 19, 1965

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors
Charles D. LaFond................Electronics
William S. Beller................Engineering

Associate Editors
Lawrence J. Curran......Assistant Managing Editor
Heather M. David..................Space Medicine
Michael Getler............................Electronics
John F. Judge................Propulsion/Materials
Robert L. Parker......................Copy Editor
Rex Pay............................Electronics
Hal Taylor..................................NASA
Donald L. Zylstra........................Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

Friedrich Schonbach...................Art Director
Donald Strickland............Assistant Art Director
Suzanne Montgomery...........Editorial Assistant
Sally Fosnight....................Editorial Assistant

BUREAUS
LOS ANGELES.....9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks...................Bureau Chief
NEW YORK....................20 East 46th Street
Michael Getler
CAPE KENNEDY ....507 Orange Ave.
Merritt Is., Fla.
MIDWEST ....423 N. Quentin
John L. Zimmerman ....Wichita, Kan.
PARIS..........................11 Rue Condorcet
Jean-Marie Riche

EDITORIAL ADVISORY BOARD
Dr. Peter Castruccio Alexander Satin
Conrad H. Hoeppner Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton............National Sales Manager
Paul B. Kinney........Eastern Advertising Manager
Edwin J. Denker, Jr.....Western Advertising Manager
Kenneth C. Blanchard.Marketing & Research Director
John N. Carlin..............Director of Circulation
Paddy Nelson................Circulation Promotion
R. Virgil Parker............Director of Production
Barbara Wiener........Advertising Services Manager

Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.

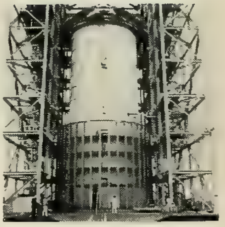
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President.......................Wayne W. Parrish
Senior Vice President..............Louis C. James
Vice President.....................Fred S. Hunter

←Circle No. 1 on Subscriber Service Card

THE COVER



Saturn V S-II stage in structural static test facility at North American Aviation's Space and Information Systems Div. The 138-ft. tower makes possible the application of structural loads similar to those the stage will experience while fueled on the pad and during flight.

APRIL 19 HEADLINES

First STINGS Test Not Total Loss 9
Air Force Gets Green Light for Pre-MOL Tests 12
April 30 Is Deadline for SRAM Proposals 12
MSFC Given Responsibility for Saturn IB/Centaur 14
Thiokol 260-in. Motor Case Bursts in Hydrotest 14
Congress Seeks More Even NASA Contract Distribution . 15
Space Power Report Outlines Mission Requirements 16
Ion Engine Restart Decision Due This Week 17

PROPULSION ENGINEERING®

Propellant Monitoring Uses Gauges in Solids 22

LIFE SUPPORT

Extravehicular Suits To Be Worn on GT-4 Flight 24

AN M/R SPECIAL REPORT

Forthright DOD Stand on CBR Advocated 27

NEW PRODUCT OF THE YEAR

Leak Detector Wins Annual M/R Contest 32

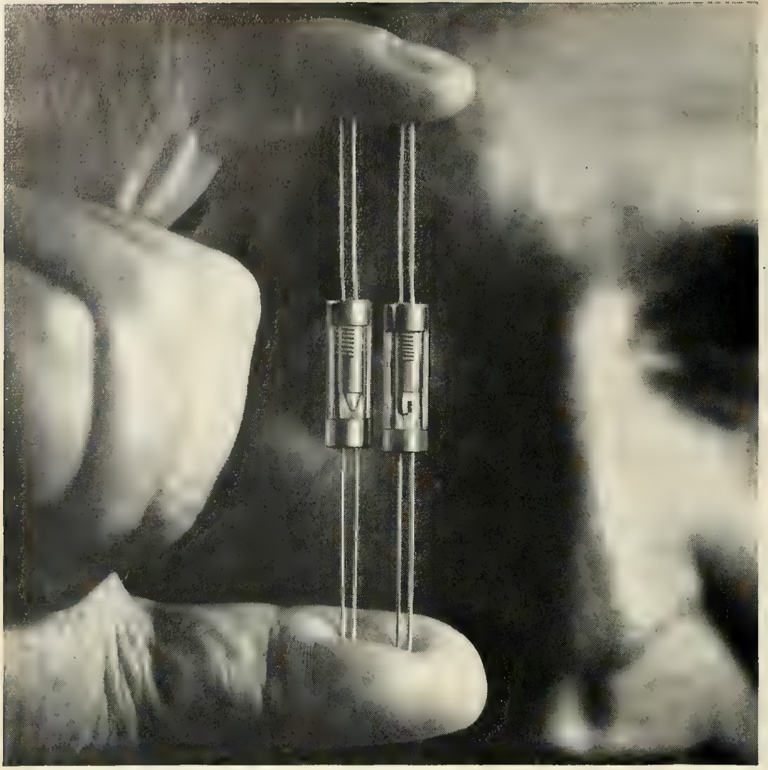
MISSILE SYSTEMS

Explosives May Aid Air-to-Air Missile Designers 34

DEPARTMENTS

Letters 4
The Countdown 7
The Missile/Space Week® 9
Technical Countdown .. 21
The Industry Week 39
Contracts/Procurements 40
Products & Processes ... 42
Names in the News ... 44
When & Where 45
Editorial 46

47,750 copies this issue



.999995 reliable

unprecedented rating by the military for Thermal Relays*

Not A Single Failure In Over 2,000,000 delivered miniature, hermetically sealed, glass-enclosed switching devices is a significant achievement. Formal recognition of the performance of these patented current-sensitive thermal relays came in December, 1964, when NASA presented its first reliability awards. Networks Electronic Corp. is one of only 15 companies out of 7,000 to be so honored for the reliability of its products in the Centaur Program.

TWO BASIC TYPES

Current-Sensitive Relays. One-shot switching devices designed on the "fuse-burn-out" principle. Normally Open or Normally Closed. Firing currents from .2 amp., and up, give wide latitude to systems designers. Can be used as current-sensitive or time-delay devices, providing variations of firing time from 2 milliseconds to 1 second or more. Ratings up to 1000 g shock and 1.69 g^2/cps random vibration characterize their extreme ruggedness.

Temperature-Sensitive Thermal Relays And Fuses. One-shot, non-resettable, Normally Open or Normally Closed swiching devices, using eutectic alloys or temperature-sensitive pellets. Operating temperature range: +150° F. to +550° F. Temperature rise (° F. per minute) – per customer specifications.

APPLICATIONS

☐ Programming ☐ Low-current sensing devices ☐ Overload protection ☐ Sequence-igniting systems ☐ Detonation devices ☐ Destruct systems.

Write, call or wire for engineering data.

NETWORKS ELECTRONIC CORP.
9750 De Soto Avenue • Chatsworth, California • Telephone 213-341-0440 or 213-873-6600
THERMAL RELAYS* • INFRARED DETECTORS • SELF-ALIGNING SPHERICAL BEARINGS

****A NASA RELIABILITY-RATED COMPANY** • Centaur Program • December, 1964*

letters

Fun and Games

To the Editor:

Bouquets of roses to you for your "Fun and Games" editorial on April 5. I wonder why the Soviet propaganda system did not pick that up—or have I missed something?

Don J. Starkey
Curator
Noble Planetarium
Fort Worth, Tex.

To the Editor:

Re your April 5 editorial, you and Mr. Hines are certainly entitled to your opinion. After all, several generations of Dirty Old Fighter Jocks and Lecherous Multi-engine Drivers bought the farm in order to guarantee you the right of editorial free speech.

However, a careful appraisal of your objections to the conduct of Peck's bad boys, Gus and John, reveals only two places where you assume they ripped their unbiased scientific knickers.

First, Gus supposedly jeopardized his position as a "control" in a food-eating experiment when he indulged in a corned-beef (bologna) sandwich. Now, if one of our brighter scientific lights has devised a technique whereby data derived from a two-subject sample (with as many variables as the food mastication/digestion matrix) can be proven statistically significant, he should share this discovery with the rest of the world. I'm sure Behavioral Scientists would be forever in his debt.

Secondly, I suggest you chew out the scientist who failed to design a simple handle for a sea urchin egg container which would not break when operated with pressure-suit-gloved hands, before you complain about flippant pilots who are unimpressed by the serious scientific aspects of space flight.

Finally, of the 45 (90) million bucks involved in the *Gemini* ride, our share as taxpayers comes to about 33.5 cents apiece. That's 67 cents for you and me combined. All Gus and John threw in the pot was their lives—don't you think for that kind of ante they are entitled to a few jollies?

James R. Milligan
Sr. Research Engineer
San Diego, Calif.

As a former Dirty Old Fighter Jock and Lecherous Multi-engine Driver himself, the editor feels he bought his own 33.5 cents worth of free speech.—Ed.

To the Editor:

Re: Fun and Games (April 5).

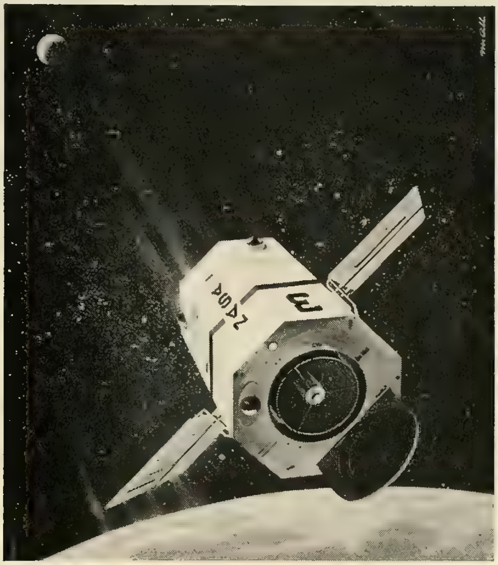
Have no fear! Gus and John will be severely reprimanded for their prank and no further incidents of this nature will occur.

But I will wager that we will be in our "no fooling around," strictly scientific, rigidly routine, Earth-bound parking orbit long after the Russians are eating their "bologna sandwiches" on the Moon.

Kenneth S. Nocito
New York City

Circle No. 4 on Subscriber Service Card

A telescope hurtling through space "anchored" on a base steadier than Mt. Palomar's?



Astronomical.

Yet true. The 22,000 part control system we developed for the Orbiting Astronomical Observatory (and successfully put through its dry runs) created entirely new design philosophies in satellite stabilization and control.

For a very good reason. To map the celestial sphere in 4 ultra-violet ranges and to accomplish the broadband photometry study of individual stars and nebulae, the 3,600 pound OAO must point its 1,000 pound instrument package with the accuracy and steadiness of earth-bound observatories undisturbed by seismic tremors.

Stiffer design requirements were posed than on any hardware yet launched. An extremely accurate celestially-oriented attitude control system must orient the astronomical telescope at any position in space with accuracies of one-tenth of a second of arc. (In terrestrial terms it's like finding a golf ball 20 miles away and tracking it for 45 minutes from a moving platform.) It will re-orient the main telescope through large angles quickly. And it is required to operate in space for one year with a 94 per cent probability of survival.

What does it all mean? Our staff of engineers, scientists and technicians at Valley Forge are doing some of the most sophisticated thinking around the aerospace industry today.

We're studying possible means for unmanned spacecraft exploration of Mars (Voyager). Not too long ago we simulated flight of 2 astronauts on a 15 day space mission, extending our knowledge of man's role in space (MOL). Another Gravity Gradient Stabilization System and another Nimbus will go up next. And our work is backed up by the most advanced, privately-owned space environment simulation facilities in the free world.

Interested?

You are invited to inquire further by writing to: Mr. J. S. Barson, Room 94-S, Spacecraft Dept., Valley Forge Space Technology Center, General Electric Co., P.O. Box 8555, Philadelphia, Pennsylvania. An equal opportunity employer.

MISSILE & SPACE DIVISION

GENERAL ELECTRIC

This is DEI's Solid State Receiver

It's new

Tunes in the range of 100 to 2300 mc

Superior performance characteristics

The TR-711 is virtually spurious free

Sets the standard for comparison

The TR-711 Receiver is modular in construction and can be supplied with a complete complement of plug-in modules including RF tuning units from 100 to 2300 mc, IF amplifiers with 10 kc to 3.3 mc bandwidths, AM, FM, and phase demodulators, and plug-in spectrum display unit, oscilloscope, predetection up and down converter, or high capture ratio discriminator. Any combination of plug-in modules can be utilized, thus providing unlimited receiving combinations adaptable to any known or projected telemetry system.

Characteristics and accessories are described in Bulletin TR-711.

Defense Electronics, Inc.
Rockville, Maryland

DEI
RESEARCH
DEVELOPMENT
MANUFACTURING

ROCKVILLE, MD [illegible] **SHERMAN OAKS, CALIF.** (213) 872 2870, TWX 213 732-2742 **COCOA, FLA.** (305) 632 5442, INT'L., **ROCKVILLE, MARYLAND.**

Circle No. 5 on Subscriber Service Card

The Countdown

WASHINGTON

Vandenberg Pad Set for MOL

Air Force plans to let a contract in October for construction of its new *Titan III* launch pad at Western Test Range headquarters, Vandenberg AFB, Calif. Operational launches of the *Manned Orbiting Laboratory* are to be conducted at Vandenberg to achieve polar orbit. The 17 *Titan III* R&D launches will be from Cape Kennedy. The WTR facility is to be ready by July, 1967, with 16 months allowed for construction and an additional four months for installation of equipment and instrumentation. Air Force has set aside $18 million in the Fiscal '66 budget for the work.

Marshall Sets Optical Satellite Studies

Requests for proposals for feasibility and design studies of an optical technology satellite will be issued by Marshall Space Flight Center within the next two weeks. Approximately $220,000 has been transferred from NASA headquarters to Marshall to fund the studies, which probably will be awarded to more than one contractor. Hardware funding for the satellite, which will be developed by the Office of Advanced Research and Technology, is expected in the FY '67 budget.

NASA Increases Incentive Contracting

NASA will shift two large *Apollo* contracts to incentive type by the end of 1965. These are for North American Aviation's Command and Service Module and Grumman Aircraft Engineering's Lunar Excursion Module. This means Manned Spacecraft Center will have at least 31 incentive-type contracts, worth a total of $5.5 billion, by the end of FY '66.

MOL Approval May Come Next Month

Approval of the program definition phase of the Air Force's *Manned Orbiting Laboratory* now is expected in late May or early June. The *Gemini/Titan* combination for use with the canister is the front-runner because of its availability earlier than *Apollo*, and also because its selection will not disrupt current programs.

New NASA Construction Contracts Ahead

Manned Spacecraft Center expects to award three more NASA construction contracts in the next 15 to 60 days. The new projects are an ultra-high-vacuum chamber, a building to house personnel working on the *Apollo* experimental program, and an addition to the crew systems division. Package will be worth about $60 million.

NASA Plans Two Unmanned Apollo Shots

NASA plans two unmanned flights to qualify the *Apollo* spacecraft with the *Saturn IB* booster, beginning early next year. First flight will be a ballistic shot with impact in the Atlantic. Second will be an orbital flight during which the Service Module propulsion system will be fired in a test of the heat shield and the entire recovery system. It is all part of NASA's new man-rating procedure, which calls for two consecutive successful flights before manned missions are undertaken.

Apollo Abort Test Set at White Sands

A high-altitude abort test of the *Apollo* spacecraft escape system is scheduled for late in the second quarter at White Sands Missile Range. Abort will take place at 110,000 ft. The *Little Joe II* booster will reach a height of 200,000 ft. and impact 120 mi. downrange. A similar flight is set for the third quarter. Last of these test flights, scheduled for the fourth quarter, will employ a flight-rated spacecraft to demonstrate the launch escape system in the power-on tumbling mode.

NASA Outlines Isotope Needs

NASA Administrator James Webb has written Atomic Energy Commission Chairman Glenn T. Seaborg detailing the various isotopes the space agency expects to use in space power devices. Webb said there is a good possibility NASA will require certain isotopes in quantities above those currently being produced. One is plutonium-238. NASA said it will support the AEC in producing up to 500 kwt by 1980. Other isotopes mentioned included polonium-210, curium-234, strontium-90 and promethium-147.

INDUSTRY

Northrop Offers Improved Sampler

Northrop's Ventura division is proposing to Defense Atomic Support Agency an improved version of a nuclear cloud-sampling system carried on its unmanned KD2R-5 drone. Proposal followed successful tests last year in which drones, mounting a cloud sampling system in a pod on each wingtip, sampled clouds during a 500-ton high-explosive detonation in Canada. Such drones could sample detonation clouds in areas where U.S. manned aircraft normally would not fly—China, in particular.

Navy Seeks Mark 46 Second Source

Sixteen industry firms have been asked to submit bids to the Navy to supply Mark 46 ASW torpedoes in a second-source procurement. Navy says mobilization requirements make it necessary to seek another prime manufacturer besides Aerojet-General, present sole source of supply. Firms solicited include: Avco, Bendix, Chrysler, Clevite Ordnance, Douglas, General Dynamics/Pomona, General Electric, Goodyear Aerospace, Honeywell, Hughes, Litton Systems, Raytheon, LTV, Martin/Baltimore, North American Aviation and Westinghouse Electric. Bids are due May 21.

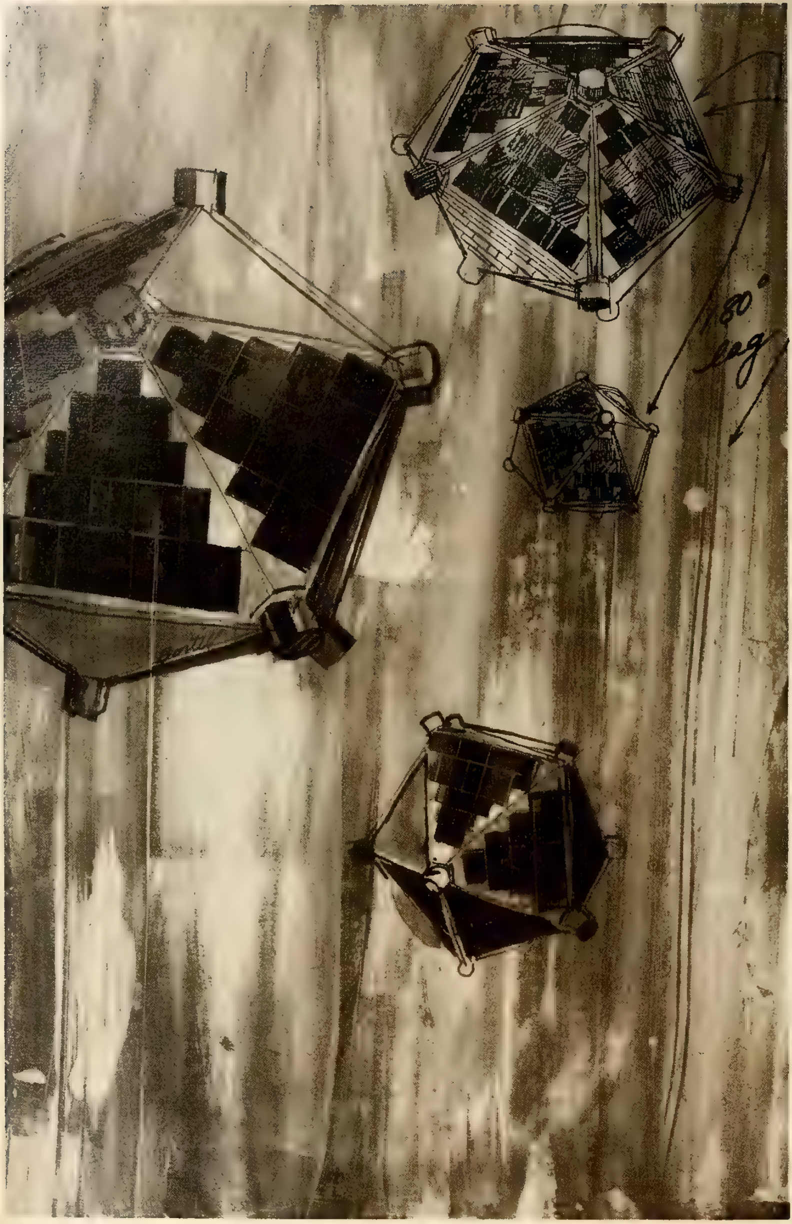
INTERNATIONAL

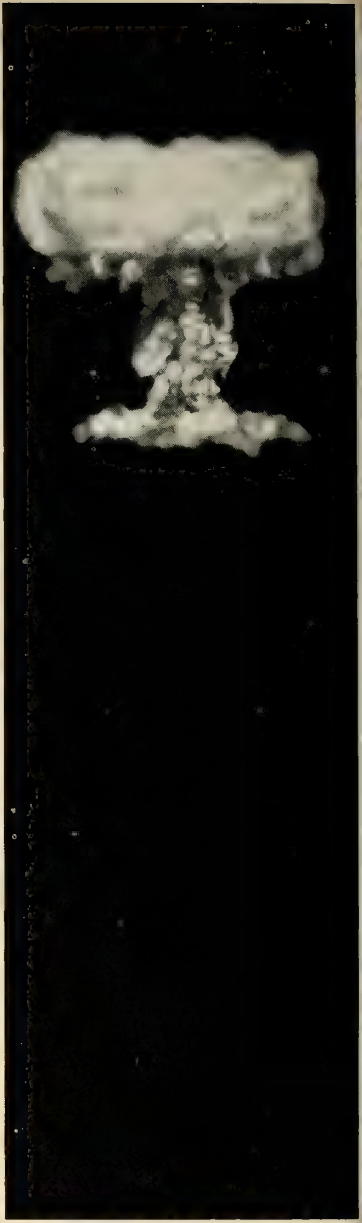
Five-Man Soviet Shot Upcoming?

Latest European rumor on the Soviet space program says a five-man shot in a new capsule is next on the schedule. Timing calls for launch ahead of the next U.S. *Gemini* launch, scheduled for June. The report was carried in a Czechoslovakian radio broadcast, quoting a correspondent who said he got his information on a trip to Moscow to interview the cosmonauts.

ELDO Continues as Planned

A French proposal to cancel the *ELDO* booster in favor of a more powerful vehicle was scrapped at a recent Paris meeting of the European Launcher Development Organization. Decision appears to confirm continuation of the original program, scheduled for 1967 completion, which calls for a Hawker Siddeley Dynamics *Blue Streak* first stage, Nord Aviation *Coralie* second stage and a German-developed third stage.





40,000 ORBITAL HOURS—AND STILL ON PATROL

These Vela nuclear detection satellites are the hardest workers in spacecraft history. Built by TRW Space Technology Laboratories, they are operating well beyond their expected lifetime to assure continuing protection from clandestine atomic blasts in space.

LOG:

Launch dates	Oct. 1963 and July 1964	Distance covered	2.5 billion miles
Time in orbit	1700 days	Program savings	$30 million

TRW SPACE TECHNOLOGY LABORATORIES
THOMPSON RAMO WOOLDRIDGE INC.

22-23

The Missile/Space Week

First STINGS Test Aborted

The first of four Stellar Acquisition Flight Feasibility (STAFF) tests planned by the Air Force ended in fiery failure 73 seconds after launch of the experiment aboard a *Polaris A1* booster April 14.

The experiment's Stellar Inertial Guidance System (STINGS) was operating open-loop and was not guiding the missile, which had to be destroyed when it veered off course. STINGS was designed for use with the cancelled *Mobile Medium Range Ballistic Missile (MMRBM)* program, but its development has been continued by General Precision Instruments, Inc.

STINGS had been locked on to the star Polaris and it tracked properly through the first 54 seconds of the flight until time of second-stage ignition, when the trouble with the launch vehicle apparently developed. The period during which the STINGS operated is the time of highest dynamic pressure, and the data received were termed "excellent."

Main purpose of the STAFF flight was to test a telescope-like device intended to eventually allow a STINGS to take a reading from Polaris after piercing the Earth's cloud cover to plot an exact trajectory to a target area.

The three remaining STAFF flights are scheduled for late May or early June, late August and late October. STINGS is to fly open-loop on these flights also.

Joint Satellite Office Formed

The Dept. of Defense has announced establishment of a Joint Meteorological Satellite Program Office (JMSPO) to coordinate requirements for such vehicles in the armed services.

Compilation of data acquired by such satellites and constant review of military meteorological needs will be the responsibility of the new office.

Under its chief, Air Force Col. Peter E. Romo, the office will be responsible for determining what kinds of participation by military agencies will be needed in future meteorological programs. Coordination of military meteorological effort with similar programs conducted by other Government agencies will also be a JMSPO responsibility. The Air Force deputy chief of staff for R&D is the reporting superior for Romo's office and DDR&E has been directed to provide overall guidance in the effort.

Tri-service representation in the new office is headed by Lt. Col. N. L. Curocher, Army; Cmdr. W. S. Houston, Navy; and Lt. Col. D. J. Eddleman, Air Force.

One Motor for Sparrow, Shrike

In response to a Navy RFP calling for a product improvement, Lockheed Propulsion Co. has submitted a proposal for design and production of a dual-purpose solid rocket motor for both the *Sparrow* and *Shrike* air-launched systems.

LPC reported that at company expense a team conducted design, engineering, production planning and more than 1,000 tests of parts and full-scale motors. Polycarbutene propellant formulation is tailored to perform within microwave attenuation requirements in the Navy specification.

Seamless Titan III-C Segment

A modified roll-extrusion process proprietary with Ladish Co., Cudahy, Wisc. and developed with company funds eliminates all welds in fabricating 120-in. solid rocket motor case segments. The 120-in. diameter, 130-in.-long segment illustrated above was formed by the process from a hot-rolled blank of Ladish D6AC—the steel used in the current Titan III-C strap-on motor case. The sample segment complies in all respects with current specifications. The modified roll-extrusion process developed by Ladish is similar to the approach taken by N.T.W. Missile Engineering (M/R March 15, 1965, p. 22). The major difference, according to Ladish spokesmen, is the ability to include the integral clevis joint construction at both ends of the cylinder.

MCC Will Direct GT-4

NASA has announced that the fourth *Gemini* mission will be directed by the new Mission Control Center at the Manned Spacecraft Center.

While the flight is still officially scheduled for the third quarter of this year, it may be launched as early as June 8.

Because of a different launch trajectory—72 degrees rather than 90 degrees—recovery area for the spacecraft will be in the Atlantic rather than the Pacific Ocean. The new trajectory was picked so that more NASA tracking stations could track the vehicle during the critical re-entry period.

The four-day flight is slated to end after the 63rd orbit. Its apogee is expected to be 187 n. mi. and its perigee, 161 n. mi.

The space agency also announced that there would be 11 experiments undertaken during the flight. Four more are being evaluated, including possible extravehicular activity.

F-1 Fired on Saturn

Test engineers at Marshall Space Flight Center are evaluating telemetry data from the successful 16¾-sec. static firing on April 10 of one of the five F-1 engines on the *Saturn V* booster.

Following analysis of the data, all five engines may be tested for a short period. Later, test firing times will be increased leading to a full-duration engine test of 2½ minutes by early summer.

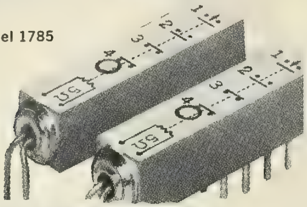
A-G Fires Sterilized Motor

Aerojet-General fired a sterilized solid JATO-type propellant previously subjected to three separate 36-hr. temperature cycles at 293°F.

The test, disclosed April 14, demonstrated that no degradation of the physical or ballistic properties of the propellant had occurred during the sterilization process. Performance of the temperature-conditioned propellant was equal in all respects to that

the Raymond multipole squib switch

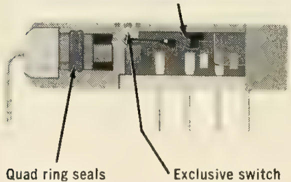
Model 1785



assures you highest reliability

with these exclusive features

Locking detent provides positive switch lock after firing to 20,000 "g's" shock.



Quad ring seals firing chamber from switch chamber.

Exclusive switch chamber purging feature.

When you specify Raymond Model 1785 you will not be troubled with poor contact resistance after firing or contact chatter during shock and vibration. You will obtain highly reliable switch actuation in 10 milliseconds maximum and positive switch lock after firing to 20,000 "g's" shock . . . all in a small size (1.573" x .375" x .375" less leads), hermetically-sealed four-pole switch available in any combination of open or closed circuits with 5 ohm or 1.8 ohm bridge resistance wire. Write for comprehensive technical literature on REL Model 1785.

CAPABILITY Raymond RELIABILITY

RAYMOND ENGINEERING LABORATORY, INC.
1011 Smith Street, Middletown, Connecticut

Circle No. 6 on Subscriber Service Card

of an identical non-sterilized propellant grain taken from the same production run and fired in another test motor.

In the company-sponsored program, Aerojet worked to the requirements established by NASA and the Air Force for solid propellants to be used for probe landings on planets.

Propellant with a proven reliability in a sterilized state will be sought for such planetary probes as *Voyager*. The formulation tested has a specific impulse of 215 seconds at 1,000 psi, sea-level conditions. The test took place March 3.

NASA Renews Support Pact

Mason-Rust has received a $10-million cost-plus-award-fee contract from Marshall Space Flight Center for continued support services at the Michoud Operations near New Orleans.

The 10-month contract provides for three consecutive one-year extensions.

The firm, a joint venture of the Rust Engineering Co. and the Mason and Hangar-Silas Mason Co., has furnished common services to both government and contractor elements at Michoud since its initial selection in December, 1961.

LMSC Gets $17M for Poseidon

Lockheed Missiles and Space Company was awarded a $17-million Navy contract for *Poseidon (C-3)* project definition. The contract represents initial funding for the missile portion of a $2-billion program, DOD spokesmen said.

Lockheed awarded $4-million each to subcontractors Hercules Powder Co. and Aerojet-General Corp.

The Navy's Special Projects Office at the same time awarded $1 million to The General Electric Co. for a fire control system and industrial support to the Massachusetts Institute of Technology for a guidance system for *Poseidon.*

ACDA Gets $30 Million

A compromise bill extending the Arms Control and Disarmament Agency for three years has been passed by the House of Representatives. Appropriations for the period through Fiscal 1968 would be $30 million.

Previously, the House authorized appropriations of $40 million for a three-year extension. A Senate amendment reduced this to $20 million for two years (M/R, Mar. 15, p. 8). The Administration had requested a four-year extension with a budget of $55 million.

Shots of the Week

The Air Force lost the first in its series of Stellar Acquisition Feasibility Flight experiments sent aloft April 14 from Cape Kennedy aboard a Navy *Polaris A1* booster (see item, p. 9) when the vehicle veered off course and had to be destroyed by the range safety officer.

● Air Force scientists launched a 30-lb. "Mini-Lab" experiment from Cape Kennedy April 9 aboard a *Blue Scout* vehicle. Purpose of the test was to determine the effect of radiation on human tissue passing through the Van Allen Belt.

OAO Pact Pending

A prototype *Orbiting Astronomical Observatory (OAO)* will be converted for launching in NASA's *OAO* satellite series.

The space agency is negotiating with Grumman Aircraft Engineering Corp., prime contractor for the program, to convert the satellite into a flight-ready spacecraft. The contract is expected to exceed $8 million.

The converted prototype will be designated *OAO A-2* and launched third in the program. First *OAO* launch is scheduled for late this year or early next year on an *Atlas-Agena.*

AF Spends $53M for Boosters

Orders for a two-year supply of basic boosters were placed last week by the Air Force.

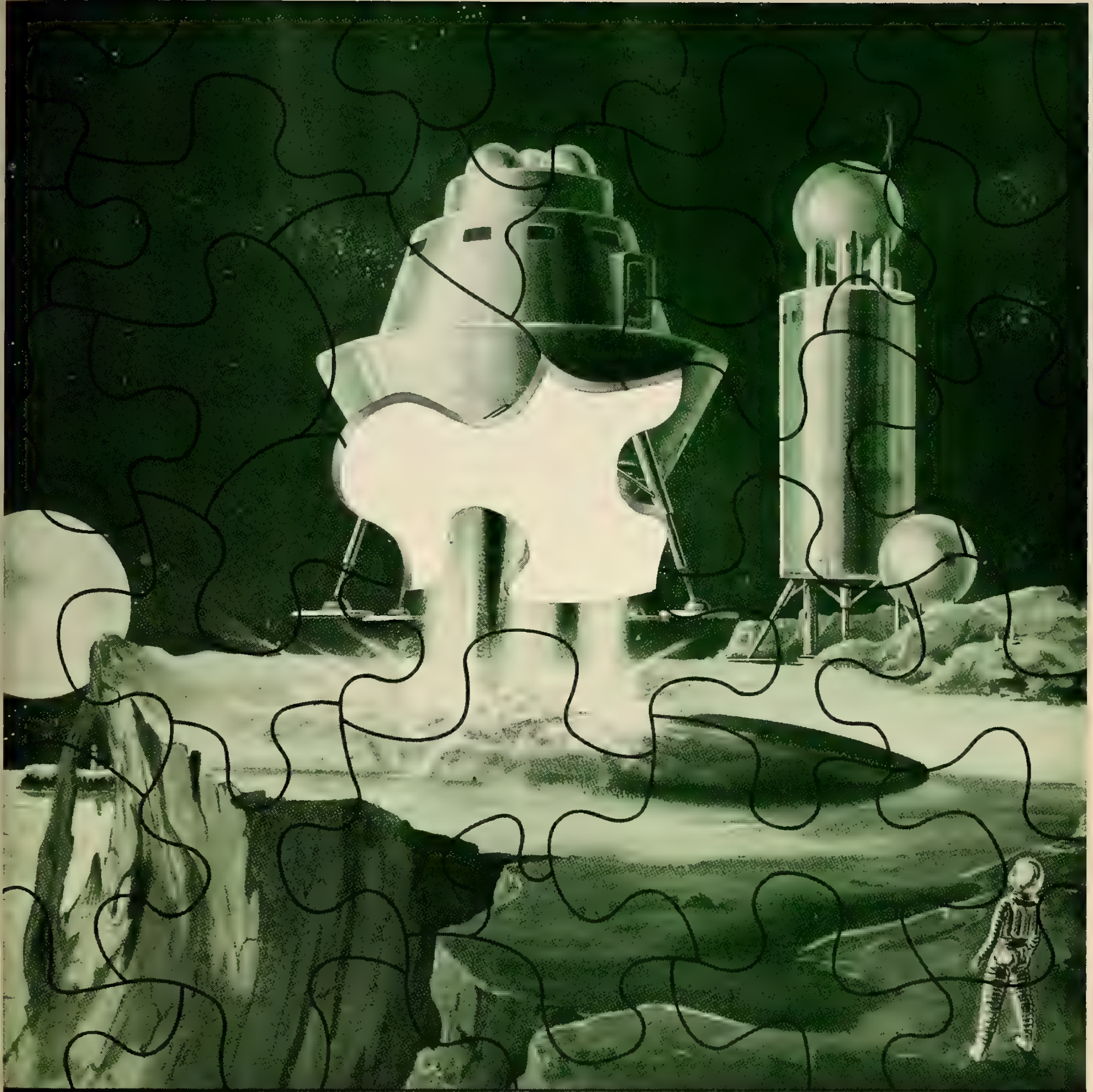
Twenty-eight each of *Atlas SLV-3* vehicles and *Thor* space boosters were ordered from General Dynamics/Convair and Douglas Missile and Space Systems Div., respectively.

The *Atlas* standardized boosters will cost some $40 million and the *Thors* a total of $13 million. The new supply of launchers are planned to fulfill 1966 and 1967 launch needs in both Air Force and NASA.

Early Bird On-Station

Early Bird communications satellite is now on-station over the Atlantic Ocean, Communications Satellite Corp. officials announced last week.

Communications tests between Andover, Me., and several European ground stations are under way. An inaugural television broadcast between the U.S. and Europe using *Early Bird* is scheduled for May 2.



Which counts more: the sum or the parts?

A successful space mission requires the focusing of many viewpoints. One man sees the capsule as dead weight to be accelerated. Others view it as a problem in control, stress, thermodynamics, life support. Each view is correct; none is complete in itself.

At United Technology Center, we specialize in propulsion. Solids, liquids, hybrids, ranging from powerful boosters to tiny, variable-thrust motors for landing or docking. Just as important, our capabilities include a deep **identification with the total mission**, not just our part of it.

Put another way, we're team players—from the first word of the contract all the way to the final touchdown.

UTC United Technology Center DIVISION OF UNITED AIRCRAFT CORPORATION

UA

ASSOCIATE PRIME CONTRACTOR FOR THE AIR FORCE'S TITAN III PROGRAM.

Circle No. 7 on Subscriber Service Card

Bleymeier confirms . . .

DOD Approves Pre-MOL Flights

Air Force to use Gemini capsule aboard Titan III-C for launches late next year; WTR firings considered

by Donald L. Zylstra

DEPARTMENT OF DEFENSE has approved Air Force plans for two unmanned launches of *Gemini* test vehicles in October and December of 1966 in an early phase of the *Manned Orbiting Laboratory* program.

Negotiations by the Air Force for modification of *Gemini* capsules to be used in the two flight tests were confirmed in an address by Brig. Gen. Joseph S. Bleymeier to the Aviation/Space Writers Assn. April 13 in Washington. Bleymeier is deputy commander for manned systems in the Air Force Space Systems Div. McDonnell Aircraft will receive the modification contract, to be negotiated through the National Aeronautics and Space Administration.

Bleymeier identified the two *Gemini* capsules as the recovered *GT-2* vehicle and Static Test Vehicle 4. The announcement confirmed DOD plans to go ahead with early portions of the *MOL* program involving the *Gemini/MOL* canister laboratory configuration, with *Titan III-C* as the launch vehicle. The proposed early test vehicles have already been procured by NASA.

Bleymeier described the flights as "pre-*MOL*."

Both an orbital and suborbital flight tests are planned. *Gemini* will be tested coupled with an oxidizer tank 10 ft. in diameter and 30 ft. long to simulate the *MOL* canister laboratory section. The suborbital flight will test the extra-thick heat shield that would be required in re-entry from the *MOL* laboratory's higher orbital altitude and provide data on the hatch to be cut in the heat shield to provide passage into the canister.

No identification was made of the specific vehicles to be used in each launch, although they will be among the 17 *Titan III* launch vehicles. Nor did Bleymeier indicate whether the orbital or the suborbital test is scheduled first. In speculating about ultimate canister configurations, Bleymeier used new dimension figures for the first time, describing the laboratory section as "10 ft. in diameter and 30-40 ft. long."

- **Modifying Gemini**—For the *Gemini* vehicles used in connection with the *MOL* canister section, modifications will include the removal of life-support and communications subsystems not needed because of the relatively brief time astronauts would occupy the capsule before transferring to the canister in space. Such alterations are expected to save 800-1,000 lbs. in total weight that might be used for more equipment in the canister section.

While the Eastern Test Range would be used for early *MOL* experimental flights because of superior instrumentation currently located there, present indications are that the Western Test Range is favored for later launches, because *MOL* program chiefs are mainly interested in polar orbits.

If manned "operational" flights are conducted from the Western Range, such plans would presumably involve installation of much new instrumentation at the West Coast facility, since all manned flights to date have been conducted from the Eastern Range at Cape Kennedy.

- **Bleymeier bullish**—Naming of a group of astronauts specifically assigned to the *MOL* program was described as imminent, "within days," Bleymeier said. He also indicated that he feels "more confident each day" that DOD will approve the overall *MOL* program as presently conceived.

Emphasis on polar orbits for *MOL* gave additional corroboration to assumptions that many of the experiments to be carried in the orbiting space laboratory will be concerned with surveillance of the Earth's surface, implying the need for the construction and maintenance of large antenna structures in space.

An Air Force Space Systems Division (SSD) study (P-14) was assigned to two industry teams, to determine the feasibility of assembling large radars and space-borne telescopes. The Fairchild Hiller team presentation was given March 26 and the Goodyear Aerospace/Hughes report, March 31. Present indications are that the use of space-borne mapping radars is believed a more effective surveillance technique than infrared or optical methods.

Mid-term presentations by the four prime competitors in the *MOL* program

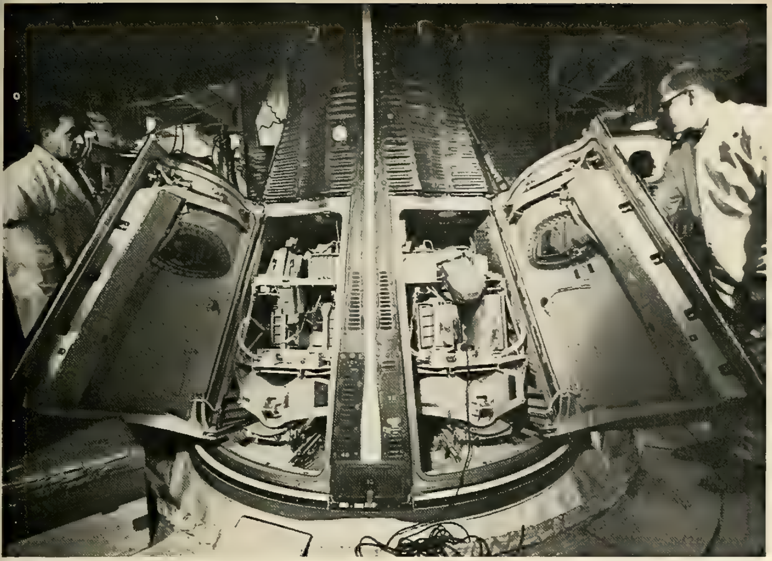
SRAM Proposals Due April 30

PROPOSALS for project definition in the Air Force *Short Range Attack Missile (SRAM)* program are due in the office of the commander, Aeronautical Systems Division (ASD), Wright-Patterson AFB, April 30. The RFP's mark the beginning of development for the air-to-surface missile, destined to be carried by the B-52 bomber and the F-111 fighter now in development.

Project-definition-phase contracts will be negotiated on a firm fixed-price basis, with following full-scale development and subsequent quantity procurement also to be conducted under some form of fixed-price contracting, Air Force sources said.

Capable of carrying a variety of warhead payloads, the supersonic *SRAM* will have a guidance system "closely integrated with the bombardment/navigation equipment of the aircraft." Development costs are expected to total between $100 million and $150 million, with $5 million allocated to the program in FY 1965. To initiate development in FY 1966, $37 million has been requested.

In addition to a team effort already announced by Boeing as the prospective prime, North American Columbus, Martin Orlando, Hughes, Honeywell, Marquardt, Douglas, Lockheed and General Dynamics are expected to submit proposals as potential primes. Boeing has announced it will team with Aerojet-General, North American Aviation Autonetics, Avco, General Precision and Textron's Dalmo Victor Co. in presenting a proposal.



GEMINI CAPSULE (GT-2) that was launched some 2,100 mi. downrange from Cape Kennedy Jan. 19 by NASA shown being checked out will be used in Air Force MOL program.

closely coincided with the antenna presentations, with teams headed by Boeing, Douglas, General Electric and Lockheed all completing their mid-term reports by April 6.

- **Rendezvous possible**—Although the original announcement of the *MOL* effort in December, 1963, specifically emphasized the absence of any need for rendezvous techniques, observers are noting a growing tendency to view the program as more of an open-end effort, not necessarily limited to six launches as originally planned. Any expansion or extension of the program is viewed as likely to include the testing of rendezvous functions in space.

A current in-house study at SSD under the Air Force directorate of development planning is considering such a possibility in connection with future space rescue concepts.

In all the effort to justify the *MOL* program to date in terms of essential manned military functions, Navy research and development people are convinced the experiment assigned to them is most easily justified in terms of military potential. Keeping tabs on ocean traffic on a world-wide basis continues to be specifically a Navy mission. Navy was given the assignment of preparing the P-13 ocean surveillance experiment for the *MOL* program.

- **Navy experiment**—This mission involves detecting, locating, identifying, classifying and tracking all surface and submerged traffic in the Earth's oceans. In embarking on this assignment, the Navy has assigned study contracts to General Electric Co., Grumman and TRW Space Technology Laboratories to define each of the five areas of the sea surveillance task.

Although Navy's original data were developed primarily on the assumption that such an experiment would be incorporated in a version of a manned orbiting laboratory using *Apollo/Saturn* hardware, instructions to the three firms conducting the studies limit them to the Air Force *Gemini/canister/Titan III-C* concept.

Its limitations on space and the development of a genuine "operational capability" point to development of a Navy experiment designed to determine how well two men in a 300-500-mi. orbit can monitor ocean traffic on the surface of the sea and below it.

Since early *MOL* canister concepts envision a compartmented unit, Navy is carrying out its experiment design placing the surveillance and station operating equipment in one half and living facilities in the other, including messing, sanitation and sleeping equipment.

Types of equipment being considered, or under actual design and development, include variable focal-length TV cameras, multiple radar systems, Earth-oriented range and view finders, electronic sensors and special communications and read-out gear.

Sensitive magnetometers, capable of long-range detection of very slight anomalies in the Earth's magnetic field; "multi-spectral sensors" able to record electro-magnetic images simultaneously in infrared, visible and ultraviolet bands; and special Earth-directed telescopes are all being considered.

Navy's Johnsville Development Center, Johnsville, Pa., has issued RFQs to industry for providing support services for the P-13 program, with replies due May 7.

- **Ocean surveillance described**—*MOL* astronauts in the canister carrying the ocean-surveillance equipment would divide their time on duty in the station between manning specific surveillance equipment and sensors and handling the station-support equipment itself. Although the experiment equipment could be handled by any astronauts with well-developed technical backgrounds, Navy notes that three Navy officers remain on the final *MOL* astronaut selection list.

Ultimately, Navy technologists envision the day when surveillance monitoring equipment in a manned orbital laboratory specifically tailored for its mission would operate in conjunction with a group of unmanned surveillance satellites, giving real-time, continuous global coverage. The unmanned craft would *locate* all sea targets but not necessarily identify them—leaving identification, classification and tracking functions to the crew of the manned vehicle.

The *Titan III-C* launch vehicle destined to lift *MOL* into its polar orbit is currently limited to a 25,000 lb. payload. But Bleymeier said the Air Force is already considering the "feasibility of substituting segmented 156-in. solid rocket motors for the 120-in. motors of the *Titan III-C*.

"Two three-segment 156-in. solids could almost double the payload capability of the system or, in other words, give us a payload in the neighborhood of 20 tons," Bleymeier said. This payload could be delivered into a 100-150-mi. orbit.

- **Uprating Titan**—In the currently non-man-rated *Titan III-X* concept, the Air Force is considering methods of uprating the vehicle by using up to seven segments of the 120-in. solid-propellant strap-on booster engines, slated for use in the five-segment configuration on *Titan III-C*. Two segments would permit payloads of 16,000 lbs, three segments would permit 18,000 lbs. and seven segments would provide a 28,000-30,000-lb. capability.

Comparable improvements in synchronous orbit and escape trajectory payloads could be achieved with the *Titan III-C*, using two 156-in. strap-ons and *Titan III-X* with multiple 120-in. segments. Consideration is also being given to using a *Centaur* instead of an *Agena* upper stage on *Titan III-X*, Bleymeier said.

Titan III is built to be launched within two seconds of a pre-selected time. The vehicle can stand on the pad in a T-minus-31-seconds condition for 30 days, with make-ready time from the assembly building to lift-off measured not in days or weeks but in terms of hours, Bleyemier said. ■

Experience dictates selections . . .

MSFC Gets Saturn IB/Centaur Job

Office of Manned Space Flight will develop vehicle; Chrysler seen as likely integration contract winner

NASA HAS ASSIGNED development of the *Saturn IB/Centaur* launch vehicle to the Office of Manned Space Flight.

MISSILES AND ROCKETS has also learned that field center responsibility for the program has been assigned to the Marshall Space Flight Center.

Both actions are expected to be announced by the space agency this week.

The selection of the Manned Space Flight Office to direct the project is unusual to a certain extent because the only mission assigned the three-stage launch vehicle thus far is part of the unmanned activity in the Office of Space Sciences and Applications.

The mission is Project *Voyager*. The *Voyager* is scheduled to make flights to Mars and other planets throughout the 1970's.

• **Why chosen**—The Office of Manned Space Flight and MSFC were apparently selected because they already have responsibility for development of the launch vehicle's S-IC first stage and the S-IV second stage.

The Lewis Research Center in Cleveland, a NASA official said, will continue to have responsibility for development of the *Centaur* third stage and will deliver the vehicles to Marshall.

NASA has requested $5 million for design studies of the launch vehicle in its FY '66 budget. As soon as the funds are approved by Congress, one or two study contracts are expected to be awarded to industrial firms and in-house studies at Marshall and Lewis will be initiated.

The selection of Marshall is almost certain to mean that the Chrysler Corp.—prime contractor for the S-IC first stage—will be selected for a new contract for the integration work required to mate the three stages.

New contracts will also be required with Douglas Aircraft Co.—prime contractor for the S-IVB second stage—and General Dynamics/Astronautics, prime contractor for *Centaur*.

• **Modification**—In addition to providing for the additional stages needed for the *Saturn IB/Centaur* flight program, the new contracts will also cover whatever structural strengthening and other changes are required to turn the previously two-stage *Saturn IB* into a three-stage booster.

Other possible missions for the new launch vehicle are unmanned lunar missions to support extended exploration of the Moon and unmanned probes of the Sun, Jupiter and Mercury.

In a related *Saturn IB* development last week, NASA announced that it had completed funding of the two-stage vehicle with the award of a $72-million contract to Douglas.

• **Additional hardware**—The California firm will supply eight *Saturn* S-IVB flight stages, in addition to the four previously contracted for by NASA, and one set of ground support equipment.

The ground support equipment at the Sacramento Test Site will be used by Douglas to ground-test the stage.

MSFC previously announced there would be 12 *Saturn IB* flights. Prior to this modification, the Douglas contract called for delivery of four S-IVB stages for the *Saturn IB* program and six S-IVB stages for the *Saturn V* program. The stage will be the third stage of the *Saturn V*.

Douglas Aircraft will receive $76,369,021 for the eight stages and one set of ground support equipment. This most recent supplemental agreement brings Douglas' S-IVB contract to a total of $311,134,662.

Douglas will perform the work at Santa Monica, Huntington Beach and Sacramento, Calif.; Huntsville, Ala.; and Tulsa, Okla. ■

Thiokol 260-in. Motor Ruptures in Hydrotest

THE 260-IN.-DIA. motor case destined for test firing at Thiokol's Georgia facility late next summer burst during initial hydrotest April 11 at the Newport News Shipbuilding & Dry Dock Co.—builders of the massive solid-motor case.

A second case, originally part of the large-solid demonstration program handled by Thiokol, is some 65% completed—but work on this case has been halted pending analysis of the possible causes of the hydrotest failure.

The 18% nickel maraging case failed at several points at an internal pressure of 540 psi. The three-cycle test would have reached pressures around 1,040 psi. A nominal 960 psi had been approved by NASA's Lewis Research Center, program manager for the large solid demonstration effort. Firing pressure would be about 760 psi.

Latest word from Newport News is that cause of the failure had not been determined, nor was it known whether the burst originated in the welds or in the parent material. Equally unknown is whether any of the myriad test conditions or instrumentation might have contributed to the failure.

The event wiped out any chance for a scheduled firing of Thiokol Chemical Corp.'s motor by August. The other 260-in. motor under development by Aerojet-General passed its hydrotest several weeks ago and is now being insulated at the firm's South Dade, Fla. booster facility.

The Aerojet case is also of maraging steel, but the welding technique used by its fabricator, Sun Shipbuilding, is the inert gas approach. The Thiokol case was welded using the submerged arc method, automatic and vertical.

Amendment anticipated . . .

Wider NASA Fund Distribution Urged

House Space Committee seeks more even geographical spread in contracting; committee's cuts may total $76 million

by Heather M. David

CONGRESS WILL MAKE clear in the 1966 NASA authorization bill its desire that the space agency spread its wealth of contracts, grants and university support more evenly throughout the country in the future.

The House Science and Astronautics Committee is expected to approve an addition to the bill urging several methods of accomplishing a more even distribution of its money over the states when it meets April 20 to vote on the authorization bill. Total amount cut from NASA's budget request in the bill is expected to reach $76 million, leaving NASA with $5.22 billion.

However, some of the items the full committee must consider in the final subcommittee report—that of the Advanced Research and Tracking group—are additions of approximately $27.2 million for the SNAP 8, 260-in. solids and M-1 programs, which were not included in the FY 1966 budget request. If the full committee should not approve the subcommittee action—which is unlikely—the total cuts would come to $100 million.

The group last week approved two subcommittee actions deleting $36.7 million from the Space Sciences and Applications portion (M/R April 12, p. 15) and $42.8 million from manned spaceflight. In the manned spaceflight cut, the subcommittee headed by Rep. Olin Teague (D-Tex.) recommended cuts of $12 million in administrative operations and construction, and $30 million for *Apollo*. (April 12, p. 16).

- **Geographical distribution**—Chief proponent of the language that would emphasize NASA's responsibility in considering research-poor sections of the country is Rep. J. Edward Roush (D-Ind.).

Roush has prepared charts that illustrate how the 20 states represented on the House Space Committee (which has 31 members) rank in receiving R&D funds. The midwest sections rank low in all categories—dollars per capita, per industrial employee, per scientist in universities, per advanced degrees conferred, per scientist, per Federal tax contributions, universities per student enrolled, and in R&D dollars distributed.

Roush has pointed up the fact that the Great Lakes region received only $250 million from NASA over a four-year period of FY 1961-1964. His own state got only $4.17 million last year or 0.1% of the space agency's total in prime awards. California, on the other hand, received $1.66 billion or 47.6% of the total, he said.

Roush also made the comparison, in a speech on the House floor, of Government R&D dollars invested in universities per graduate degree conferred. Nevada is top with $195,600, he said, while his own state gets only $3,400 per graduate student.

The Congressman pointed to a seven-state area which contains almost 25% of the nation's population and produces more than 25% of the advanced degrees conferred in the physical sciences, mathematics, and engineering. However, this area, including Illinois, Indiana, Ohio, Iowa, Wisconsin, and Michigan, ranks low in R&D dollars per university, he indicated.

Another midwestern Congressman, Rep. Weston Vivian (D-Mich.), suggested earlier that NASA be required to award one-half of its Phase I contracts to states low in NASA funds. However, such a strong measure is not expected to be adopted by the full committee.

Another sore point with Midwestern House members on the space committee is the fact that NASA has no operations office for the area. Some of the Congressmen feel that the Northeast Operations and Western Operations offices, which are designed to aid contractors in receiving awards and bidding upon contracts, gives industry in those areas an undue advantage. Some moves to force the establishment of such an office in the Midwest have been made.

The amendment to the bill appears to have the support of most committee members and is not expected to be opposed by those who do not actively support such measures. ■

	R&D $ per Industrial Employe	Per Scientist in Universities	Advanced Degrees Conferred	R&D $ per Scientist	Federal Tax Contribution	Per Capita	R&D $ Distribution	Universities per Student enrolled
California (3)	3	3	4	2	4	3	1	6
Connecticut (1)	21	14	23	19	20	12	21	12
Florida (2)	10	27	17	33	12	13	9	31
Georgia (1)	41	26	21	33	43	34	33	24
Illinois (2)	36	7	8	27	34	22	13	7
Indiana (2)	37	38	47	31	37	27	26	34
Louisiana (1)	7	28	25	12	7	10	15	33
Massachusetts (1)	20	5	6	13	13	9	3	4
Michigan (1)	33	16	34	26	39	25	19	21
Minnesota (1)	26	19	14	21	24	20	25	17
New York (4)	18	9	20	16	25	11	2	10
North Carolina (1)	46	32	31	34	44	31	29	25
Ohio (2)	32	30	27	25	30	23	14	35
Oklahoma (1)	35	36	44	37	41	31	36	39
Pennsylvania (1)	24	18	18	20	23	18	5	19
Tennessee (1)	17	20	36	14	15	16	18	32
Texas (2)	13	24	29	18	18	17	6	36
Virginia (1)	23	31	15	21	26	24	24	30
Washington (2)	8	17	12	6	6	7	7	16
West Virginia (1)	43	41	46	38	40	33	42	47
Lowest Rank	50	50	50	38	46	34	50	50

ABOVE FIGURES represent state ranking in geographical distribution of research and development funds in eight categories of comparison. Numbers in parentheses represent number of Congressmen on House Space Committee from state listed.

In space power report . . .

SNAP Systems Get New Emphasis

Lunar and planetary missions to require power measured in hundreds of kilowatts; funding may be maintained

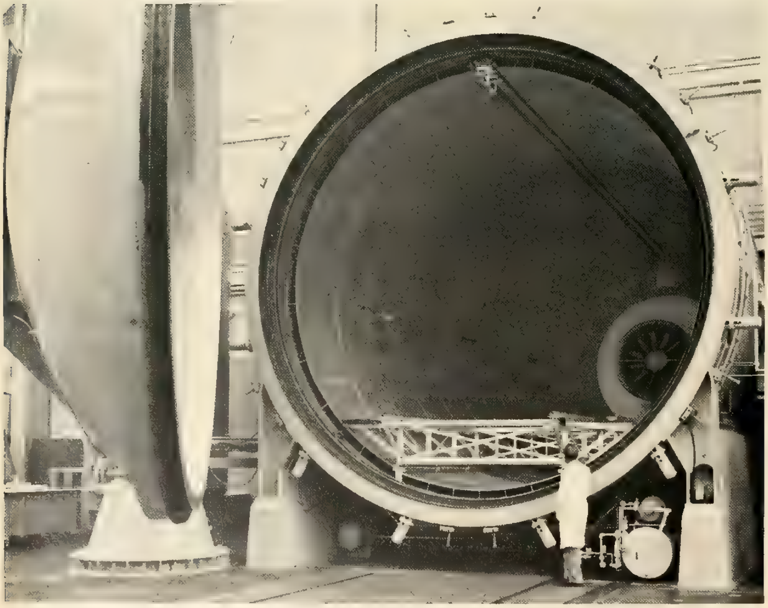
by Hal Taylor

A SPECIAL space power report prepared for the joint NASA/DOD Aeronautics & Astronautics Coordinating Board may put new life into the SNAP 8 and SNAP 50 nuclear systems.

The report—prepared by Defense Dept., NASA and Atomic Energy Commission personnel—surveyed the current U.S. space power program and its future requirements. It predicted that in the 1970-75 period, NASA and DOD will have 15 new mission possibilities under consideration which would require power in the tens of kilowatts range.

It added that the possibility of extended lunar explorations in the 1975-80 time period imply power levels in the hundreds of kilowatts and deep space probes and manned interplanetary missions in the 1980's suggest power levels in the megawatt regime.

As far as power requirements in the kilowatt range, both SNAP 8 and SNAP 50 could fill them. Both programs have been limping along with reduced funding and priority because of lack of a mission requiring them. The report—which points out that there are 15 possible missions—may aid Congressional supporters of the projects to maintain funding at a level at which the systems could eventually reach flight-test readiness.



Autoclave Used in Apollo Readied for Work

AUTOCLAVE that bonds honeycomb-core panels for NASA's Apollo spacecraft Lunar Excursion Module adapter and Service Module structure is prepared for operation at North American's Space and Information Systems Div. Tulsa, Okla., facility. Adapter doubles as "garage" for LEM and as interstage between Apollo spacecraft and third stage of Saturn V booster. The autoclave was built for NAA by Fuel Engineering Div., Textron, Inc., Torrance, Calif., and is said to be the largest resin-bonded autoclave in operation. It has an inside diameter of 20 feet.

- **Mission requirements**—The projection of the 1970-75 requirements were based on anticipated and potential missions. The estimate of 1975-80 missions was based on what the panel called possible or desired capabilities.

The assessment of the 1960-70 requirements was far more definitive because it was based on programmed, planned and probable missions. The report said that requirements in that time period are characterized by a predominance of applications for power levels—almost 50%—in the range of 0.01 to 0.5 kwe for durations in excess of six months. The most numerous applications are for power levels from 0.1 to 0.4 kwe. Almost all applications are unmanned.

The final report—written by William H. Woodward, deputy director of NASA's Nuclear Systems and Space Power Div., and Air Force Lt. Col. Lew Allen, staff assistant to the assistant director for space power in DDR&E—said that its prediction of future requirements was not based on official DOD or NASA documents. It said they are probably optimistic because budgetary constraints will prevent approval of all suggestions. The predictions do have a certain amount of credibility because the government officials making up the panels have access to future program plans in all three agencies.

- **Details missing**—The report did not detail what the possible future missions might be, primarily because of the classified nature of most DOD missions. It was also believed that by lumping both NASA and DOD agencies into a general number of missions, leaks about the exact number of DOD missions could be prevented.

In discussing the SNAP 8 program—which will be continued if Congress votes it extra funds in NASA's FY '66 budget—the report said that the total cost for the ground development program may approach $200 million. This includes over 40,000 hours of power-conversion system testing, over 30,000 hours of nuclear and simulated reactor system testing, and over 20,000 hours of integrated system testing. The latter includes operation in the NASA Space Propulsion Facility.

It is estimated that the presently planned ground development program will be completed in 1970. The report said that to adapt SNAP 8 to specific manned missions will require an additional three to five years. Possible missions considered for the system include lunar base, large orbiting space stations and deep space probes.

As far as the SNAP-50 program is concerned, it said the program now calls for a ground test to demonstrate feasibility in 1972.

"The Air Force is conducting mission studies to determine potential requirements and vehicle integration studies to define the key problem areas. Flight tests, which are as yet unscheduled, will be conducted by the Air Force," the report continued.

The cost of the ground development program through the first demonstration test is estimated at $350 million. Total cost through flight and reliability testing, the report said, is on the order of $1 billion.

• **Study inputs**—The study is based on some 20 technical papers and comments thereon which have been prepared by recognized authorities from industry, universities and the government. Three panels, comprised of DOD, NASA and AEC personnel, as appropriate for each technical field, reviewed the basic material on solar, chemical and nuclear systems. In addition to the three systems panels, a requirements panel surveyed potential DOD and NASA future missions.

This report integrates the findings of the four panels with those of the authors and focuses attention on the more significant problems, conclusions and recommendations.

The unclassified basic material is available from the Power Information Center, University of Pennsylvania, Philadelphia. Additional copies of the report may be requested from The Scientific and Technical Information Facility, P.O. Box 57, Bethesda, Md. 20014, Attn: NASA Representative, or the Defense Documentation Center, Cameron Station, Alexandria, Va.

• **Recommendations**—Its major recommendations included:

Thermoelectric efforts should be concentrated on investigations supporting nuclear rather than solar or chemical applications.

Solar thermionic systems should be considered primarily for planetary or other applications where in-shadow operation is at a minimum. Further, the work should be directed toward diode efficiency and life improvement. With regard to nuclear thermionic systems, effort should also be directed primarily to efficiency and life improvement on diodes configured for reactor applications.

Solar dynamic system development should be paced by progress in the fabrication, launch and deployment of large-area, stable concentrators that possess reasonable weight and collection efficiency.

More emphasis should be placed on the reliability factor in selecting long-lived systems for ultimate development. For example, reliability factors suggest that dynamic systems should be considered primarily for applications where some necessary advantage is to be derived from their use.

Increased emphasis should be placed upon improving secondary battery performance characteristics. Development of better seals and separators as well as an increase in basic electrochemical research directed toward better understanding of alkaline couple reactions is needed.

Exchange of information between systems-development groups and supporting research and technology groups within the various agencies should be improved. Particular attention should be given to ensuring that supporting research and technology information emanating from development projects is reported in a timely fashion to the appropriate research and technology groups. In addition, consideration should be given to broadening the membership of the IAPG to include system development representatives from the various agencies.

Steps should be taken to establish more uniform security classification policies that can be adopted by the DOD, AEC and NASA.

DOD, AEC and NASA should adopt a more streamlined and unified procedure for nuclear safety reviews.

The interagency exchange of information during the program planning phase should be improved until coordination comparable to that existing between programs in being has been achieved. ■

Ion Engine Decision Due This Week

A DECISION is expected this week on whether to restart the ion engine now orbiting with the Atomic Energy Commission's SNAP 10A reactor.

Decision to restart the prime secondary payload will be based on hand analysis of data received during the short time the Electro-Optical Systems engine was functioning. For the first seven minutes after start-up, operation of the ion engine appeared normal. But when high voltage was applied, some electromagnetic noise was introduced to the telemetry system. After the ion engine was turned off, telemetry went back to normal. It was found, however, that several telemetry points on the SNAP were affected.

Aside from the problems with the ion engine, AEC officials said the SNAP system is operating nominally. At 9 p.m. PST April 9, it was put on static control for automatic operation. As of April 14, power output was about 600 watts. This is expected to decrease gradually as the temperature decreases. All flight objectives have been met thus far, except proving out the 90-day operational capability of the SNAP/*Agena* orbital system.

It was also disclosed last week that overall cost of the SNAP 10A program has been $111 million to date, including AEC and Air Force funding. A back-up SNAP unit had been provided in case this month's shot was unsuccessful, but there are no current plans to launch it.

Other payloads orbited with the SNAP and ion engine included an electrical structures experiment; an ionosphere beacon experiment that was jettisoned at about 700 miles altitude; an erosion gauge; a micrometeorite detector (two hits were reported during the second day of operation) and an impedance probe.

Orbital parameters were given as near normal. Apogee is 717 n. mi., perigee is 699 n. mi. and period is 111.6 minutes. Nominal orbit was 700 miles circular.

AEC said these firsts were achieved: first reactor auxiliary power system in space; first *Agena* dual burn without active assist (*Agena* burned seven minutes, then coasted and restarted for 10 seconds to achieve circularized orbit. This was accomplished without the use of ullage rockets.); a nose-up stabilized *Agena;* first radiation hardened satellite system; and first off-loading of *Agena* fuel.

Spacecraft tracking is being done at stations in Hawaii, New Hampshire and at Vandenberg AFB.

Ampex
guarantees:

these premium A&B oxide tapes will make standard bandwidth instrumentation recorders perform better.

If that doesn't surprise you, this might: now you can buy the long-wear, heavy duty Ampex tapes at standard, regular-wear prices. No recorder—old or new—will give maximum performance if you're using run-of-the-mill tape. Now you can forget about making do with ordinary tapes because of cost limitations. You can buy premium, heavy duty Ampex A and B oxide instrumentation tape—guaranteed to deliver optimum performance on most recorders—at standard, regular-wear tape prices. Ampex A and B oxide is not only long wearing, it gives you better short wavelength response than standard tapes. It's not only conductive and anti-static, it's cleaner running than standard tapes. It not only reduces head wear and dropouts, it gives you more uniform output and higher resolution than standard tapes. Ampex tape and standard tapes really have only one thing in common: their price. Order today, or write Ampex Corp., Redwood City, California, for full details.

INSTRUMENTATION
AMPEX MAGNETIC TAPE

© AMPEX CORP. 1965

AMPEX

Circle No. 8 on Subscriber Service Card

Technical Countdown

ELECTRONICS

Laser Space Communication Problems Critical

Laser platform stability will have to be improved by at least two orders of magnitude to achieve satisfactory satellite-to-Earth optical communications, says B. C. Bowers, in the April issue of *British Communications and Electronics*. Yet, this appears impossible, he said, in view of the uncertainty of the magnitude of forces in the satellite operating environment. Aiming and tracking, he pointed out, are critical and the solution of such problems could determine the rate of progress in achieving laser communications.

Poseidon Subsystem Needs Are Extensive

Introduction of highly sophisticated penetration capabilities into the *Poseidon* missile system is expected to require major improvements in the already developed *Polaris* fire control, guidance and computation system. The on-board missile guidance system, for example, while probably remaining as a three-gimbal design such as the current *Polaris* system, is expected to require new types of inertial components—gyros and accelerometers. The on-board computer, now a special purpose device, may require expansion large enough to demand use of a general purpose computer. Modification to the Mk-84 submarine fire control system, observers say, could amount to an effort almost half the size of that required to develop the original *Polaris* system.

Surveyor Camera Has Heaters Added

Being scheduled for the end of 1965, initial Surveyor flights have no choice but to land in lunar night. This is acceptable, NASA scientists say, because these are primarily missions to test the spacecraft in transit to the Moon and during the landing sequence, not to carry out reconnaissance from the lunar surface. However, Jet Propulsion Laboratory would still like to have the on-board survey camera operate during approach, and even after landing, if possible. This has led to the decision to modify the camera to bring it up to a minimum operating temperature of −20°F. Electric heaters are to be added and the camera will be given low-emissivity external surfaces.

SPACE MEDICINE

New Drinking Water Source Unearthed

Water condensates recovered from the heat exchangers of pressure suits could be used as an emergency source of drinking water for astronauts, a study at the School of Aerospace Medicine shows. In a two-week study, two Air Force pilots wore ventilated, full pressure suits and lived in the space cabin simulator. Samples periodically collected from the heat exchangers of the pressure suits showed that the moisture collected was potable if used immediately. However, after storage, it was found that the water was of an unacceptable bacteriological purity level.

AF On Liquid Diets

It is becoming increasingly likely that the Air Force will use liquid diet forms for manned spaceflight when the time comes. Latest in a series of tests is one in which two volunteer airmen at USAF School of Aerospace Medicine are subsisting on a new nutritional substance which is similar in form to a vanilla milkshake but supplies all their dietary requirements for space station operation. The substance, being tested in a month-long simulator confinement, consists of proteins, three different sugars, fats, minerals and vitamins and distilled water, and furnishes about 2,500 calories daily.

Bioinstrumentation Methods Studied

Seven new instrument techniques are being studied by North American Aviation's Space and Information Systems Division as part of the contract just awarded by NASA's Electronic Research Center for remote bioinstrumentation devices for space use. NAA is looking at: 1) infrared thermometers to detect astronauts' temperature from a distance; 2) a remote detector for sensing skin changes; 3) a measuring device for input and output of gases in the space suit; 4) displacement sensors to measure pulse waves on the surface of the skin; 5) a microphone so sensitive it can detect heart beat and respiration remotely; 6) a device to measure energy changes of a beam transmitted through the astronaut's body; and 7) photo sensors to determine breathing rate by detecting the change of light reflected from the astronaut's chest.

MATERIALS

Polymer Resembles Solid Fuel and Hot Metals

California Institute of Technology is working under Air Force and NASA sponsorship with a transparent rubber-like substance in an effort to devise a standardized material that can simulate the mechanical behavior of solid rocket propellants and heated metals. The material, originally developed by Thiokol Chemical Corp., is a polyurethene polymer and can be made in any shape and with a large range of viscosities in order to simulate various other materials. Caltech researchers are interested in standardizing such a material so that it may be used for investigating stress analysis problems in many areas and more economically than is currently possible.

Structural Test Facility under Construction

A structural test facility for evaluating large scale models of advanced flight vehicles is being built at the Flight Dynamics Lab, Wright-Patterson AFB. The AF Systems Command installation will have programming equipment capable of simulating actual flight missions in tests covering development structures for vehicles using cryogenics for propulsion and cooling. Flights will be programmed for low-angle, high-speed re-entry or for lower speeds and various re-entry angles while test equipment programs and controls the actual fuel conditions and levels. Checkout equipment will include the AN/GJQ-9 Automatic Checkout sequence programming set manufactured by Bendix Corp. and originally slated for the *Skybolt* missile.

Chemical Work Engine Perfected

An engine that converts chemical energy directly to mechanical energy has been developed by Professor Aaron Katchalsky, head of the Polymer Research Department of the Weizman Institute of Science with Air Force Office of Scientific Research support. The device operates on a lithium bromide salt solution, obtaining continuous rotary motion with an output of about one-third watt. It is believed to be the first to make such a conversion without intermediate forms of energy.

Navy Propellant Monitoring Technique Employs Gauges Embedded in Grains

By John F. Judge

A METHOD OF continuously monitoring internal temperatures, strains and stresses in solid-propellant rockets during the cast, cure and storage cycles is being used to improve processing at the Naval Propellant Plant, Indian Head, Md.

NPP researchers predict that with further refinements the technique could serve as a non-destructive quality assurance tool for evaluating motor reliability.

In the field, this would lead to procedures to determine grain integrity without transporting the missile to an inspection facility.

The NPP approach involves burying tiny gauges in the grain before starting the crucial cure cycles. Static firing an instrumented 40-lb. motor established the feasibility of firing grains with embedded instruments.

The investigations into this processing improvement are being done at NPP's research and development department by L. Danziger, A. H. Klein and P. R. Mosher.

One direct result of their studies is the adoption of an improved cure cycle in the NPP pilot plant areas. Preliminary data indicates this cure change—a result of stress/strain/temperature monitoring—is reducing 40-lb. motor rejection rates from 15% to about 6%.

- **Work several years old**—In-grain monitoring started at NPP several years ago as part of a process improvement effort. The work was carried out simultaneously with other studies so that propellant grains could be obtained with improved physical properties and reducing defects.

Temperature gradients within subscale motors were successfully monitored using standard thermocouples and recorders. But stress measurements proved far more difficult because of gauge and instrumentation problems.

These difficulties were overcome by NPP researchers through modifications in the circuitry to provide adequate temperature compensation and non-drifting signals.

After an intensive evaluation process, NPP workers settled on a miniature pressure transducer—Consolidated Electrodynamics' Model 4-325. Another gauge suitable for such monitoring work has since been developed by Gulton Industries, but the NPP work was accomplished with the Consolidated unit.

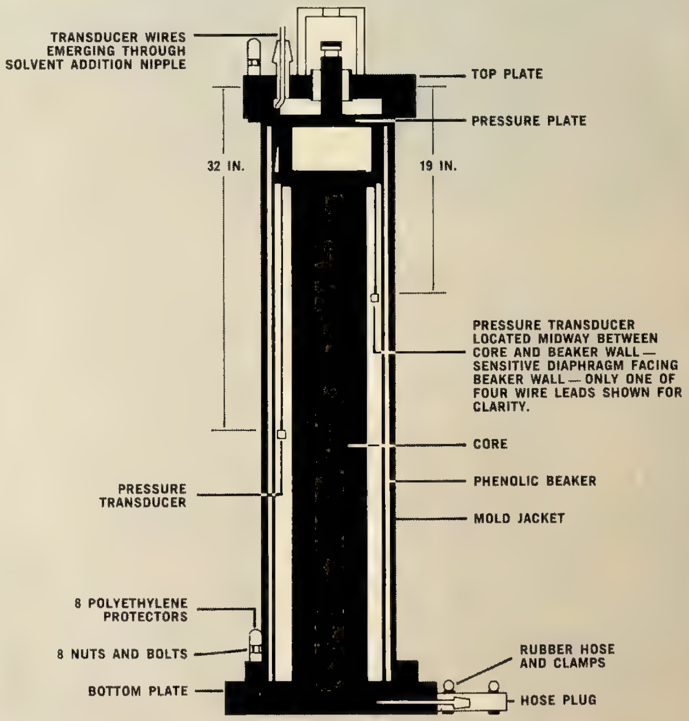
The initial program involved the measurement of internal stresses occurring in subscale motors during processing. Internal propellant stresses were determined and then the relationships among these stresses, the process variables and grain quality, were developed.

Processing changes were then introduced—improving the subscale motors curing technique and reducing case bond separations.

- **Gauge description**—The Consolidated Electrodynamics Model 4-325 gauge is a disc-shaped transducer weighing 0.33 oz. and measuring 0.75 in. across and 0.33 in. high. It is an unbonded strain gauge type instrument using a spring sensing element with four active arms attached to a force-summing diaphragm.

In operation, pressure (or vacuum/pressure in absolute pressure models) exerted against the diaphragm produces a displacement which changes the resistance of the active arms. The resulting electrical output caused is precisely proportional to the applied pressure.

The four-active arm, Wheatstone-Bridge design of the sensing element is symmetrical and thermally balanced—minimizing effects of temperature, vi-


TRANSDUCER WIRES EMERGING THROUGH SOLVENT ADDITION NIPPLE
TOP PLATE
PRESSURE PLATE
32 IN.
19 IN.
PRESSURE TRANSDUCER LOCATED MIDWAY BETWEEN CORE AND BEAKER WALL — SENSITIVE DIAPHRAGM FACING BEAKER WALL — ONLY ONE OF FOUR WIRE LEADS SHOWN FOR CLARITY.
CORE
PHENOLIC BEAKER
PRESSURE TRANSDUCER
MOLD JACKET
8 POLYETHYLENE PROTECTORS
8 NUTS AND BOLTS
RUBBER HOSE AND CLAMPS
BOTTOM PLATE
HOSE PLUG

bration and acceleration sensitivity.

- **Improvement through monitoring**—Twelve composite modified double-base type charges of about 120-lb. size were monitored through pressurized ambient temperature and heated cure cycles. Eight of these units provided data that statistically defined the best path for improving the subscale curing technique.

The next four units generated data to confirm the effectiveness of these proposed changes.

Ambient cure varied between one and three days with 70 psig piston pressure applied. The heated cure was four days at 140° F with piston and casting solvent pressures at 70 and 30 psig, respectively.

After monitoring these twelve grains, additional 40- and 10-lb. motors were processed without internal gauging to determine the effect of the indicated improved cure cycle on ballistic and mechanical properties.

Examination of the eight-motor data revealed that all but two units had resultant internal pressures at the end of the cure cycle some 3 to 5 psig below the starting reference pressure.

The NPP investigators initially theorized that this condition of negative pressure present in the grains represented a shrinkage tendency of the propellant from the case bond—and thus an indication of case bond-propellant separations.

- **False conclusion**—Correlation of final grain pressures with X-ray and visual examinations of the motors, however, showed that the two grains with final pressures near the starting pressures were poor and could not be static fired because of large case bond-propellant separations.

The six grains with negative pressures had no visible separations and were suitable for test firing.

The explanation is that grains with relatively large negative pressures were still under tension because of the propellant's shrinkage and retained bonding to the case.

Those motors with internal pressures near the initial reference had experienced case bond separations and were in a relaxed condition.

Referring back to the cure cycle conditions, the NPP researchers were able to trace a preferred route through the cure cycle. In this example these changes involved shortening the length of ambient cure to one day, releasing the solvent pressure one day prior to start of cool-down and releasing piston pressure one day after completion of cool-down.

Four confirmation motors followed the predicted pattern when two of these used the improved cycle and the other two were deliberately processed under non-optimized conditions.

Ballistic and physical properties of motors processed under the optimum conditions were compared with non-optimized processed units. The two optimized motors were within the subscale specifications, and two others revealed defects as predicted prior to test.

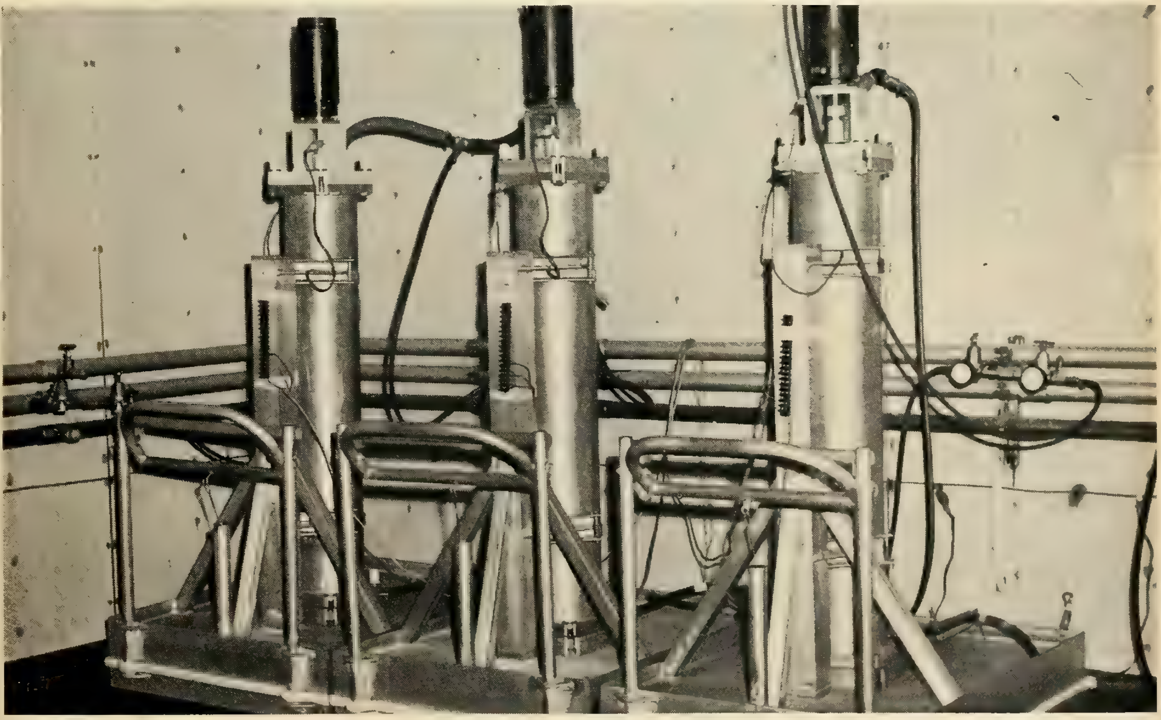
The in-grain monitoring technique has been established as a tool for the accurate prediction of propellant-to-liner separations prior to mold disassembly and grain inspection—in addition to helping define cure cycles.

- **Future applications**—Further studies and refinements will move the technique into certain aspects of ballistic testing. Applications in larger rockets—including glass-wound motors—appear attractive.

The NPP researchers have mastered techniques allowing the passage of gauge leadwires through both glass-wound and metal motor cases without weakening the case. The same is true of metal pressure vessels.

The technique can obviously be extended to monitoring the long-term storage and surveillance testing of solid motors—providing information on internal grain conditions that otherwise would escape early detection by conventional means. ■

LEFT: Diagram of test set-up used in studying the internal temperatures, strains and stresses occurring during the cure cycles of composite modified double-based propellants. RIGHT: Three of the 40-lb. motors showing strain gauge connections during the curing process in the Patterson Pilot Plant at the Naval Propellant Plant.



GT-4 Crew To Wear EVA Spacesuits

Tests completed in McDonnell chamber; White wears suit in 'open hatch' drill; MSC says, however, first extravehicular activity is slated for GT-5

by Jinx Mercer

EXTRAVEHICULAR spacesuits identical to one just rushed through tests at NASA's Manned Spacecraft Center in Houston will be worn by the *GT-4* crew during the second manned *Gemini* mission in early June.

In rigorous MSC chamber tests recently, the suit successfully endured −300°F temperatures at simulated space altitude of 240,000 ft.

Final tests qualifying the suit were performed last week to exercise the extravehicular activity (EVA) suit under rapid decompression.

During manned altitude runs of the *GT-4* spacecraft in McDonnell Aircraft Corp.'s space chamber, the crew carried out the first step in MSC's conservative EVA program (M/R, May 18, 1964, p. 31). Edward White, co-pilot for the *GT-4* mission, depressurized the spacecraft at 240,000 ft., opened the hatch, stood up and looked out. White wore an EVA suit made by David Clark Co., Inc.

MSC spokesmen said, however, that the first extravehicular activity "is scheduled for *GT-5*."

• **Pacing item**—The EVA program outlined a year ago had to be revised when the EVA suit ran into unexpected development problems. Charles W. Mathews, *Gemini* program manager, confirmed that the suit was the pacing item in the program as late as January of this year.

Charles C. Lutz, of MSC's Crew Systems Div., said micrometeoroid and thermal protective layers are now integrated into the basic *Gemini* spacesuit.

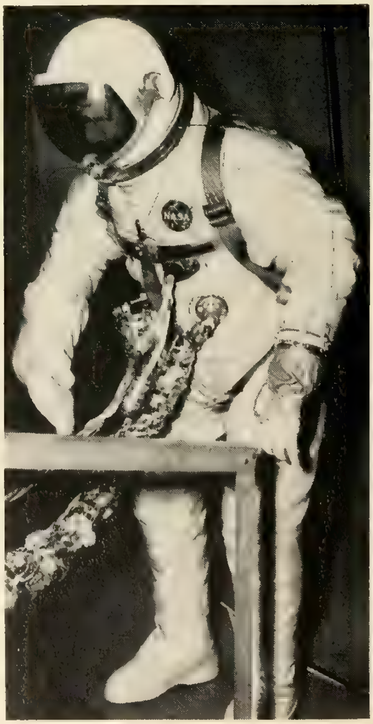
Along with micrometeoroid protection, described as "woven felt," there are thermal layers consisting of aluminized polyester film (Mylar) .00025 in. thick interspersed with layers of loosely woven polyester fiber (Dacron) scrim. Aluminized Mylar reflects heat, while the loosely woven Dacron separators resist heat conduction.

Lutz said the top layer remains unchanged from the *GT-3* suit. He described this layer as 100% nylon woven from Du Pont HT-1 fiber.

Early problems with the EVA suit centered upon integrating thermal protection into the basic *Gemini* suit. Seams compressed the thermal layers and created "hot spots." Lutz said this problem was resolved by offsetting the seams layer-to-layer.

The EVA portion is laced to the basic *Gemini* suit, Lutz explained. Heat leaks around fittings are kept to a minimum with pouch-like cups to shield metal from direct radiation from the Sun, he said.

SUIT TECHNICIAN James M. Skipper prepares to enter 20-ft. space chamber at NASA's Manned Spacecraft Center for "dry run" of extravehicular spacesuit. Mitten on subject's right hand will be replaced with glove having same micrometeoroid and thermal protection as suit. Galoshes are to prevent soiling of suit during ground operation. Parachute harness will be disconnected, but not removed, during "open hatch" operation, MSC said.



"We don't want the suit to leak more than 250 Btu's per hour, in or out," Lutz said.

A man at rest produces 500 Btu's per hour. When he is highly active, the figure climbs as high as 1,000 Btu's per hour. This means that heat loads to be handled by the suit-cooling system generally will range from 500 to 1,250 Btu's per hour.

The visor area of the helmet is the greatest source of heat leak, he said. A thermal coating (made by Libby-Owens-Ford Glass Co.) was applied to the outside of the Plexiglas, giving the visor a yellowish tint. An anti-fog solution was used to coat the interior of the face plate.

• **Lesson from Gus**—Lutz said the face visor was beefed up from .080 in. to .125 in. to resist impact of the type that broke Virgil ("Gus") Grissom's face plate when his head whipped forward during main parachute descent of the *GT-3*. The spacecraft pitched down abruptly when the release was made from single to two-point suspension to reposition the spacecraft for splashdown.

The co-pilot will lower a sun visor over his face plate prior to "hatch open" operations to protect his eyes from glare, Lutz said. Infrared and ultraviolet radiation will be partially filtered by the Plexiglas. MSC, however, is looking into better materials for the sun visor, Lutz said. "Some polycarbons, such as Lexan and Merlin, look promising," he commented.

The EVA suit may undergo other changes. In particular, the suit will be provided with better flame protective material to resist plume impingement from thrusters contained in the Air Force's back-pack propulsion unit. This Dept. of Defense experiment is scheduled to be conducted late in the *Gemini* program. ■

TWO GREAT NEW CHAMPS

NEW COAX

Recording 1.5 mc on as many as fourteen tracks, Mincom's new Portable Coaxial Recorder offers the industry's highest performance per cubic foot. Stands under two feet high. 14-inch NAB precision reels. 1⅞ to 120 ips. Two playback channels. RFI-shielded, this new system is unequalled for van, shipboard and similar installations.

NEW PCM

Digital data in an improved parallel format at 120,000 bits per second per track—that's the story of Mincom's newest solid-state system. Sixteen channels for NRZ digital input, clock, timing and voice. Seven push-button speeds from 1⅞ to 120 ips. Controls and adjustments front-accessible for CRT display and digital electronics.

Mincom Division 3M COMPANY
300 South Lewis Road, Camarillo, California

Circle No. 9 on Subscriber Service Card

Going to Mars this summer?

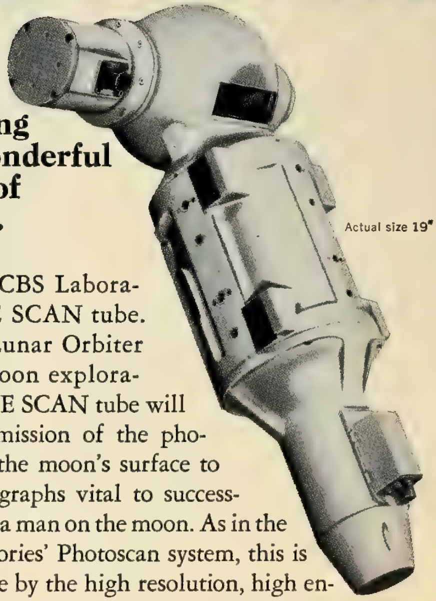
Or perhaps you're flying to the moon?

this keeps its eye on a star to make the going smooth.

Actual size 6⅞"

This is the CBS Laboratories' RECONOTRON® tube. It is accurately stabilizing Mariner IV on its 7½ month journey to Mars by fixing an electronic eye on the star Canopus. Without it, Mariner IV might roll on its long axis. The unique star-tracking device, of which the CBS RECONOTRON is the heart, was developed by the scientists and engineers of NASA's Jet Propulsion Laboratory. Another example of CBS Laboratories contributing to the national space effort.

this is perfect for sending home wonderful pictures of your trip.



Actual size 19"

This is the CBS Laboratories' LINE SCAN tube. When the Lunar Orbiter makes its moon exploration, the LINE SCAN tube will enable transmission of the photography of the moon's surface to Earth. Photographs vital to successfully landing a man on the moon. As in the CBS Laboratories' Photoscan system, this is made possible by the high resolution, high energy spot it generates. While previous lunar photographs were transmitted only before impact, the LINE SCAN tube will operate continually while the spacecraft orbits the moon. Developed by CBS Laboratories, the LINE SCAN tube is being utilized in the Lunar Orbiter Satellite with the cooperation and technical guidance of Kodak and Boeing.

You may not be going to Mars, but a little bit of Stamford, Connecticut is. It's CBS Laboratories' contribution to Mariner IV. The RECONOTRON tube. As, for moon travel, the LINE SCAN tube, another CBS Laboratories development, will be going with the Lunar Orbiter for moon exploration.

Both the RECONOTRON and LINE SCAN tubes were designed by the Electron Tube Department of CBS Laboratories to meet the highly specialized needs of space vehicles. But you don't have to be planning a trip to outer space to take advantage of our special facilities.

If the tubes you want aren't on the shelf, don't compromise your electronic system. For any special tube in the area of light emitting, sensing and image conversation, contact CBS Laboratories. You'll find us as eager to help as your travel agent.

CBS LABORATORIES
Division of Columbia Broadcasting System, Inc.
High Ridge Road, Stamford, Connecticut

An M/R Special Report

Forthright CBR Policy Urged

An examination of the principal chemical and biological agents—and their effects—available in modern weaponry

by William S. Beller

THE INCAPACITATING GASES used three times these past few months by South Vietnamese troops to subdue the Viet Cong are having their most telling effects on U.S. Department of Defense officials.

From members of the Office of the Secretary of Defense down, no one is able to utter a word about any aspect of chemical, biological or radiological (CBR) warfare. This is remarkable, since the Army has pleaded for the past two decades for more public understanding of its efforts in CBR warfare. And DOD is budgeting about $125 million for further CBR work during Fiscal 1966 (M/R, March 29, p. 58).

It is even more remarkable in view of (1) the Soviet Union's continuing effort to train its entire population in CBR defenses, and (2) that country's notion that "a future war . . . will be characterized by the massive use of . . . various means of mass destruction such as atomic, thermonuclear, chemical, and bacteriological weapons." This statement was made by Marshal G. K. Zhukov, former Soviet Minister of Defense, at a party congress in February, 1956.

Commenting about DOD's attitude, an officer formerly in charge of the Army's CBR work said: "Our government is making a big mistake in retreating so precipitously from the use of incapacitating gases (in Viet Nam)." Brig. Gen. J. H. Rothschild, USA (Ret.), told MISSILES AND ROCKETS that in the final analysis, "it was a completely humane act." He indicated it is better for troops to get a little sick to their stomachs than to have no stomachs at all.

- **Chemical warfare**—Much of the unclassified data on CBR warfare are of 1960 vintage. Since that time, only bits and pieces of updated material have been published in the open literature. New chemical agents have possibly been discovered—especially those that could grossly affect a person's mental stability—but no official word about these or any others has come out.

Like explosive warheads, chemical weapons can be tailored for the job at hand. Some of them, for instance, can be used in an attack on an area target to cause as many casualties as would a medium-yield nuclear bomb.

Other chemical weapons can be employed in attacks on tactical targets, particularly those in hard-to-reach places such as caves and dense forests. They can even be used to subdue enemy troops mingled with civilian population.

Some of the gases—including the well-known mustard—can have a persistent effect on the target. How much and how long an effect depends on the type of gas used and its distribution. An appropriate agent could, for example, block the passage of troops through jungle paths.

One of the big advantages claimed for gases is that they do not affect real property. For this reason, friendly people presumably would not be alienated if they were exposed to a non-lethal gas attack.

Chemical agents can be deliverd in many ways. The *Sergeant* and *Corporal* tactical missiles can carry them. They can also be sent by grenade launchers, or, for close-up work, by hand-thrown grenades. Crop-duster-type aircraft are particularly useful for covering large areas with chemical agents, while helicopters, releasing gas from canisters over smaller areas, can push it toward the ground by rotor wash, as was done recently in Viet Nam.

- **Most deadly**—Nerve gases, the most deadly of chemical weapons, have brought another element into strategic warfare, which stems from their being so much more lethal than earlier war gases. The median lethal dosage of one of the nerve gases, Sarin, for instance,

PROPERTIES OF CHEMICAL AGENTS

NAME OF AGENT U.S. SYMBOL	PHYSICAL STATE AT 68° F.	DISSEMINATED FORM	MEDIAN LETHAL DOSAGE ON INHALATION* MG.-MIN./M.^{3}	MEDIAN INCAPACITATING DOSAGE ON INHALATION MG.-MIN./M.^{3}	TIME OF ONSET OF SYMPTOMS	PHYSIOLOGICAL ACTION
PHOSGENE CG	Colorless gas.	Gas	3,200	1,600	Immediate to 24 hours.	Damages the lungs.
TABUN GA	Colorless to brown liquid.	Aerosol, liquid or gas.	400 (resting men) 100 (active men)	300 (resting men)	Inhalation; Very rapid. Skin: ½-1 hour.	Anticholinesterase agent (nerve gas).
SARIN GB	Colorless liquid.	Gas or liquid.	70 (mild activity) 25 (active men)	35 (mild activity)	Inhalation: Very rapid. Skin: ½-1 hour.	Anticholinesterase agent (nerve gas).
VX	Colorless liquid. (persistent)	Aerosol or liquid.			Inhalation: Very rapid. Skin: ½-1 hour.	Anticholinesterase agent (nerve gas).
MUSTARD HD	Colorless to pale yellow liquid.	Gas or liquid.	1,500 (resting men) 400 (active men)		Delayed 4-6 hours.	Injures eyes and lungs. Blisters skin.
CS	White crystalline solid.	Aerosol.			Instantaneous.	Extreme burning and tearing of eyes. Difficult breathing. Stinging of skin. Nausea.

* Concentration times exposure (milligrams per cubic meter times minutes) to cause death in 50% of subjects. The numbers are directly comparable to indicate lethality of the agents.

From *Tomorrow's Weapons* by Brig. Gen. J. H. Rothschild © 1964. Used by permission of McGraw-Hill Book Co.

is only 25 mg-min/m^3 for active men. This contracts with 400 mg-min/m^3 for mustard gas and 3,200 mg-min/m^3 for phosgene.

Under field concentrations of 10 times the median lethal dosage, easily obtained in small areas for a short time, one inward breath of Sarin would kill. In lesser amounts, the gas would take about a minute to dispatch an unprotected human.

The figures given are a direct measure of lethality. They indicate the gas concentration (mg/m^3) over a time period (min.) that will cause death in half of the exposed subjects. Since the amount of nerve gas needed is small, it is possible to effectively use these chemicals in ICBM warheads or as payloads in strategic aircraft.

"Such long-range delivery of toxic chemical weapons must now be considered to be a real threat," an Army official told the American Chemical Society as long ago as 1960. He went on to say, "This threat may well increase in intensity as even more potent chemical weapons are discovered, as they surely will be with continued research in this field."

This is borne out by some European work in the synthesis of poisons. Working with the class of ethers of dialkylalmino-alkylthiophosphinic acid, a Scandinavian chemist reported that about 2 mg on a man's skin was lethal. He did not say how much less would be needed if the chemical were put in aerosol form and inhaled.

● **Gingerly handled**—Chemical weapons include incendiaries and smokes as well as toxic agents and riot-control gases. All of these were used in World War I. During World War II and the Korean War, neither the toxic agents nor riot-control gases saw action for aggressive purposes; however, riot-control gases were used to keep groups of POW's in line.

Most of the world's concern with respect to chemical warfare centers around the nerve gases. It is well known that Tabun, the first of these, was synthesized by Dr. Gerhard Schrader in 1936 in Germany, while he was working with I.G. Farbenindustrie searching for a potent insecticide. Tabun was followed by Sarin and Soman, members of the same phosphoro-organic series and highly toxic. The potency of Tabun is dramatized by the fact that it would take 75 tons of mustard gas to equal one ton of nerve gas in casualty effect.

The Germans never used their nerve gases, perhaps because they feared the Allies would retaliate. This fear was groundless: at the time, only Germany had these weapons. After the war, the Soviet Union captured and moved to its own soil a German Tabun plant. The United States, on the other hand, adopted Sarin because it is about four times as lethal as Tabun in the same concentration.

In the United States, the nerve gases are given the prefix "G." Tabun is known as "GA," Sarin as "GB," and Soman as "GD." They are all colorless, odorless and tasteless. The only positive warning that they give is the convulsions and sudden death of troops. A signal flashed to troops further down the line with an order to mask would be the only protection.

An antidote to the inhalation of a small amount of nerve gas is an injection of atropine tartrate. Every U.S. soldier in a battle area carries a 2-mg tube of the substance, which is pushed against a large muscle or the clothing and is injected automatically. However, the injection must be given within seconds after exposure to the gas; if there has been large exposure, massive doses of the antidote must be used, plus artificial respiration.

● **How it works**—Only a small quantity of nerve gas is needed to kill because the chemical strikes at an enzyme in the human body. When shrapnel tears a limb off a human the chances are that he will live, but if an enzyme is destroyed, the biochemical workings of the body are altered and can easily be fatal.

Enzymes are the catalysts that promote biochemical reactions that otherwise would go so slowly life could not be maintained. Formed in the body's cells, all the enzymes discovered so far are proteins.

Nerve gases attack the enzyme acetylcholinesterase and inactivate it. Found in the blood and nerve tissue, this enzyme converts acetylcholine to acetic acid and choline. This action takes place whenever a voluntary muscle is moved. For a man to raise his arm, the appropriate nerves must release acetylcholine to put the arm muscles in motion. The enzyme, meanwhile, breaks the chemical down to its components. For the arm to continue to move, more acetylcholine must be released. Arm motion stops when the flow of acetylcholine ceases and is completely catalyzed.

Nerve gases, blocking the catalytic action of acetylcholinesterase, bring the muscles to a chaotic state of motion, like a machine without a governor. The vital organs of the body, including the lungs, become involved in a tug-of-war of the muscles, and—as in most anarchistic systems—death results.

A class of nerve gases less volatile than the "G" agents are known as V-agents. A tiny droplet of one of these on a man's skin can be absorbed without pain or other notice, and cause death. V-agents can be disseminated in aerosols or mists, and even though troops may be masked and protected by clothes, minute amounts of the agent may be transferred to the skin when they unmask or change clothes. Because V-agents are not very volatile, they can be used on the foliage of forested trails, in barracks, or any place where the presence of troops is to be discouraged.

● **Out of action**—Incapacitating gases may be divided into those which make a person physically incapable of carrying on, and those that make him mentally incapable. The former class includes chemicals that can cause permanent damage, such as mustard gas and phosgene, as well as those causing temporary physical incapacities.

The gases used in Viet Nam—forms of tear gas and nausea-inducing gas—are temporarily incapacitating. They include DM, described by Defense Sec-

RELATIVE EFFECTS OF CBR WEAPONS

(As prepared by the American Chemical Society Committee on Civil Defense 1960)

Basic assumption. One B-52 bomber (or its equivalent) can carry either one 20-megaton thermonuclear bomb or enough CW or BW agent to create the comparable results shown in this table.

	NUCLEAR AGENTS	CHEMICAL AGENTS	BIOLOGICAL AGENTS
IMMEDIATE EFFECTIVE AREA	75 to 100 sq. miles (A & B rings)	100 sq. miles	34,000 sq. miles at very least and with only 450 lb. of agent
HUMAN LETHALITY (OR MORBIDITY) IN IMMEDIATE AREA (UNPROTECTED)	98% (lethality, A ring)	30% (not necessarily lethal)	25 to 75% (morbidity not necessarily lethal)
RESIDUAL EFFECT	6-month fallout with additional 1000 sq. miles of area	3 to 36 hours (nearly same area)	Possible epidemic or epizootic spread to other areas
TIME FOR IMMEDIATE EFFECT	Seconds	7½ sec. to 30 min.	A few to 14 days
REAL PROPERTY DAMAGE, IMMEDIATE AREA	Destroyed (nearly 36 sq. miles)	Undamaged	Undamaged
VARIATION IN EFFECT	Little	Wide, need not kill, only incapacitate	Wide, need not kill, only incapacitate
TIME AGRESSOR CAN SAFELY INVADE AREA AFTER ATTACK	3 to 6 months	Immediately	Immediately after incubation period

retary Robert S. McNamara as a pepper-like irritant that affects the eyes and mucous membranes, and causes sneezing, coughing, headache, tightness in the chest, nausea and vomiting. It incapacitates a subject for a half an hour to an hour.

CN is a lacrimatory agent as well as an irritant to the upper respiratory passages, and it may also irritate the skin. It puts a man out of action for about three minutes.

The third gas used in the Viet Nam action is CS, a recently developed lacrimatory agent which is more of an irritant than CN, and usually causes chest pains. Its effects last from five to ten minutes.

About 10 years ago, a new class of incapacitating agents—the psychochemicals—began to take form. These attack a soldier's ability to perform by temporarily confusing his mental processes. This was brought out dramatically in a film clip shown to the House Committee on Science and Astronautics during 1959 testimony on the effects of some of the psychochemicals.

In this clip, said the Committee report, "a cat receiving the new drug was so reversed in character that it was in great terror of mice in its cage, cowering and leaping about wildly to keep its distance from the mice." In another clip seen by the Committee, troops exposed to one of the agents became so removed from the real world they were unable to follow simple orders or do simple tasks. Yet the men did not recognize what had happened to them—only an unexposed outsider would have known.

- **LSD 25**—Among the compounds available as psychochemicals are lysergic acid derivatives, known in one instance as LSD 25, psilocin and mescaline.

The effects of LSD 25 are difficult to predict since they depend so much on the subject's state of mental and physical health at the time he is exposed to the chemical. The extremes range from euphoria to manic depression. "During a single exposure," Rothschild writes, "an individual may progress from the deepest feeling of impatience, restlessness and anxiety, to a highly exaggerated sense of well-being; from delusions of persecution or grandeur, to a catatonic state in which he lacks the will to talk or move, but which may be punctuated by violent outbursts, hallucinations or panic."

Doses of LSD 25 as low as 0.05 mg can bring about these effects, which usually appear in about a half an hour and disappear 12 hours later without any after-effects.

Psilocin, first obtained from a species of hallucinogenic Mexican mushroom, produces effects similar to those of LSD 25 but not as easily.

Mescaline, a simple compound found naturally in portions of a small cactus plant, is used by Mexican Indians as a mild intoxicant during special ceremonies. Deep hallucinations are brought about with doses of 30-50 mg.

The "latest and best (pyschochemical)," known as BZ, was described earlier this year by reporter Richard Fryklund in the Washington *Evening Star*. He told of a soldier on guard duty exposed to BZ: "He was approached by a strange soldier who said he did not know the password. The guard tried to remember what to do about it, couldn't, got tired of the whole problem, and sat down and went to sleep."

- **Future of BW**—Biological warfare (BW) is insidious not only because of its indiscriminate and widening effects, but also because there is no simple way to tell the difference between BW and a natural but unexpected epidemic. Moreover, every country with sufficient technical knowledge to support a biology laboratory can grow cultures of virulent biological agents.

They can easily be disseminated anywhere in the world by simple sabotage —such as introducing them into the air-conditioning ducts of a building—or by aircraft, missiles or any carrier in which excess heat is not developed and the agents are not overly exposed to sunlight.

An American Chemical Society study of 1960 has found that only 450 lbs. of biological agent dispersed by "one B-52 bomber" would have an immediate effective area of 34,000 sq. mi. "at (the) very least." By the same token, a 20-megaton thermonuclear bomb would effect between 75 and 100 sq. mi.

BW agents are apt to be drawn from one or more of five classes of microorganisms, according to a House Committee report:

—Fungi would be most effective against a nation's food crops—although San Joaquin Valley Fever is a fungus infection that can attack man.

—Protozoa are a possibility, but are difficult to grow and to transmit. Sample diseases of this type are malaria and amebic dysentery.

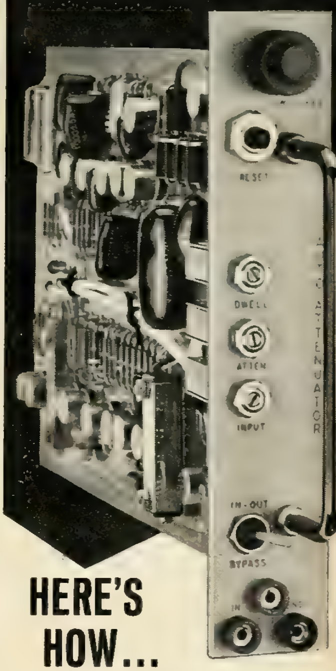
—Few bacteria are harmful, but some important disease types exist—anthrax, brucellosis, glanders, tularemia, plague, bacillary dysentery and cholera.

—Another group are the rickettsiae, including typhus, Rocky Mountain Spotted Fever and Q Fever.

—Viruses must certainly be considered in BW, particularly those causing influenza, psittacosis, and Venezuelan equine encephalitis.

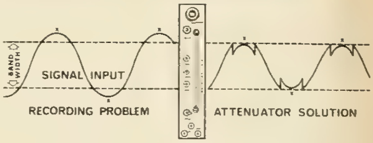
Besides living organisms, there are toxins—the poisonous products microorganisms may form. The best known of these results in botulism poisoning. ■

NOW
DOUBLE THE
DYNAMIC RANGE
OF YOUR RECORDERS!



HERE'S
HOW...

The SANGAMO Type SA-2L
Automatic Attenuator



- Broadens—even doubles—the effective dynamic range of your recorder.
- Permits recording of information previously impossible to obtain.
- Allows for transients without sacrificing low-level data . . . no need for costly channel sharing.
- Can be easily added to existing oscillographic or magnetic tape recorders.
- And, best of all, the cost per channel is unusually low.

Get the full story . . . write, wire or phone.

SANGAMO

ES65-3

SANGAMO ELECTRIC COMPANY
P.O. Box 359, Springfield, Illinois 62705
Phone: 217 544-6411 • TWX: 217 546-0947

Circle No. 11 on Subscriber Service Card

Leak Detector Wins M/R Competition

GE-developed unit heads list; Awards of Honor won by Perkin-Elmer, 3M Co., h nu systems and Defense Electronics

A LOW-COST, portable leak detector for use on ultra-high vacuum systems is the winner of the annual Missiles and Rockets New Product Of The Year competition for 1964.

Developed by engineers at General Electric's Vacuum Products Operation, Schenectady, N.Y., the lightweight leak detector can be plugged into the recorder output of any pressure-measuring device or ion pump with an output between 0.1 and 1 volt.

The battery-operated GE detector was selected after a careful review of hundreds of product announcements as the New Products of the Week for the issue of Sept. 7, 1964. The annual competition pits each weekly selection with all others during M/R's 51-week publishing year.

The device operates by amplifying the difference between the pressure response of a probe gas sprayed over the leak and the characteristic pressure response of air. The difference is indicated to the leak detector operator by a change in audible tone transmitted through a set of earphones.

When coupled with the proper pressure gage under ultra-high vacuum conditions, leaks down to 10^{-14} torr liters/sec. may be detected.

Four Awards Of Honor were also announced by M/R Editor William J. Coughlin. The runners-up and their new products were Perkin-Elmer, Norwalk, Conn. with a continuous-wave gas laser; 3M Co., St. Paul, Minn. for its thermal conductivity apparatus; h nu systems, inc., subsidiary of Energy Systems, Inc., Palo Alto, Calif., with an ultra-precision universal laser; and Defense Electronics, Inc., Rockville, Md. with the TR-711 solid state receiver.

- **Perkin-Elmer**—Perkin-Elmer Corp.'s Model 5300 continuous-wave gas phase laser features hot-cathode d-c discharge excitation and produces approximately 8 milliwatts in the diffraction-limited mode and about 15 milliwatts multimode.

Normally supplied with reflectors for visible red-light output at the 6328-angstrom wavelength, the unit is also available with readily interchangeable reflectors for infrared output at 1.15 or 3.39 microns.

The resonator consists of an 88-cm optical cavity. Brewster angle windows of the highest optical homogeneity terminate the gas plasma tube. Minimum-loss multilayer dielectric reflectors are used for maximum power output.

- **3M Co.**—Superior measurements of the rate of heat transmission through a variety of basic materials is now possible with the thermal conductivity apparatus developed by 3M Co.

The instrument uses a steady state comparative method of measurement matching the thermal conductivity of an unknown material against a known control. Accuracies are within ±5%.

Test temperature ranges are from 25° C to 1,200° C and require samples only an inch in diameter. The unknown sample is sandwiched between two identical standards with known thermal conductivities. By properly adjusting seven heaters on a guard tube, radial heat flow is eliminated and the same amount of heat flows through all samples in the axial direction.

A thermal balance point is reached when the temperatures at specific points on the sample column are within one degree of the respective points on the guard tube.

- **h nu systems**—The second laser among the winners is an ultra-precision universal laser, Model 3000-P developed by h nu systems, inc. The device has one basic cavity and power supply capable of meeting any of 400 wavelengths. Precision micrometers projecting from the sides of the instrument provide all of the desired optical cavity adjustments. The cavity is available with any of the pulsed or CW laser tubes previously announced by h nu systems to generate 400 distinct wavelengths from the far infrared through the entire visible spectrum and into the ultraviolet.

The cavity has micrometers capable of dual-speed operation with graduations equivalent to 20 micron movements.

Maximum active plasma tube length is achieved through the use of re-entrant resonator reflector supports and special boots ensure dust-free chambers around the Brewster windows.

The precision of the angular positioning devices is such that one division of the micrometer equals 0.2 seconds of arc. The necessary total angular range for mirror adjustment is provided by additional gross adjustments included in the mirror support mount.

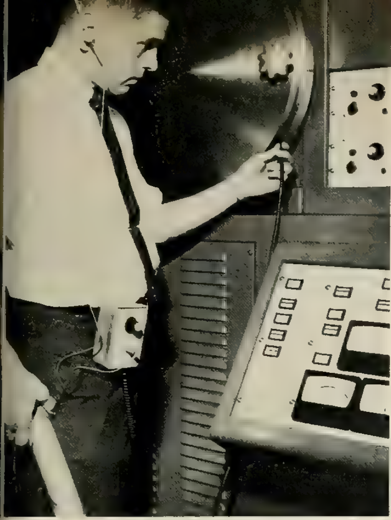
The angular adjustment is augmented by an extremely precise linear adjusting mechanism permitting changing the cavity length. Thus the operating frequency can be continuously varied so that frequency changes on the order of a few kilocycles out of 500,000 kilomegacycles can be achieved.

- **Defense Electronics**—The Model TR-711 solid-state telemetry receiver developed by Defense Electronics, Inc. represents an order-of-magnitude improvement in strong signal handling and a reduction of spurious responses common in previous solid-state receivers.

The unit is modular in construction and can be supplied with a complete complement of plug-in modules, including RF tuning units from 100 to 2,300 mc, IF amplifiers with 10kc to 3.3mc bandwidths, AM, FM and phase demodulators, and plug-in spectrum display unit.

A rear-apron 30-mc input connector allows the TR-711 to be used as a 30-mc receiver in conjunction with any tuning unit or device having a similar output frequency.

Power transformers and reactors in the receiver are hermetically sealed. Provisions have been made for front-panel-activated latch release mechanism when used with standard equipment slides. ■



GE BATTERY-OPERATED audible leak detector won annual M/R contest.

MODEL 5300 helium-neon laser produced by Perkin-Elmer won an Award of Honor.

THERMAL conductivity apparatus from 3M.

DEFENSE ELECTRONICS' solid-state receiver, winner of an Award of Honor.

ULTRA-PRECISION universal laser completes Award of Honor winners.

SENIOR SCIENTISTS & ENGINEERS...

unusual opportunities at RCA Moorestown

The Missile and Surface Radar Division, Moorestown, N.J., has exceptional openings that demand the highest level of technical and creative skills. If you are this type of recognized senior specialist, now is the time to join an organization that is known for its pursuit of professional excellence.

Senior specialists are needed in the following areas:

FLUID DYNAMICIST . . . Develop programs defining electromagnetic properties in flow fields generated by a ballistic and/or manned vehicle during hypersonic re-entry into planetary atmospheres.

WEAPONS SYSTEMS ANALYSTS . . . Pursue conceptual and theoretical work in weapons systems studies and development work related to new business.

MISSILE GUIDANCE SYSTEMS ANALYSTS . . . Pursue original concepts for new business proposals and development programs, conduct special studies and provide technical focal point for missile guidance technique requirements.

ELECTRO-MAGNETIC and MATHEMATICAL ANALYST . . . Pursue conceptual and theoretical work in fields of electro-magnetic theory and mathematical analysis of problems in radiation, scattering and diffraction of radar frequencies.

RADAR SYSTEMS SPECIALIST . . . Pursue conceptual and developmental work in electronic phased arrays, antennas, range instrumentation and/or weapons systems, radiation and propagation and advanced technologies associated with radar systems.

Experience required for these positions ranges up to ten years and academic attainment from an MS to Ph.D. Critical for each opening is solid exposure to the discipline and a record of continuing creative contribution.

To test your qualifications for these openings, and to arrange an interview with engineering management, send your resume to:

Mr. W. J. Henry, Dept. V-14
Missile & Surface Radar Division
Radio Corporation of America
Moorestown, New Jersey

RCA®

The Most Trusted Name in Electronics

An Equal Opportunity Employer

Circle No. 12 on Subscriber Service Card

LOOK AT
LOCKHEED
...IN
GUIDANCE

Research and development in the technology of Guidance is not confined to any one discipline. Broad interests and exceptional capabilities are required, as typified by the following:

GUIDANCE—Ability to formulate guidance laws for missile and spacecraft missions. Familiarity with digital simulation techniques and calculus of variations or methods of steepest descent.

VIBRATION/ACOUSTICS—Develop environment criteria for structural designs from ground and flight data. Advance the state-of-the-art in vibration and acoustical prediction methods.

METEOROLOGY—Perform fundamental studies in turbulence, ground winds, and other natural environments. Understand the latest instrumentation, data acquisition and data analysis techniques.

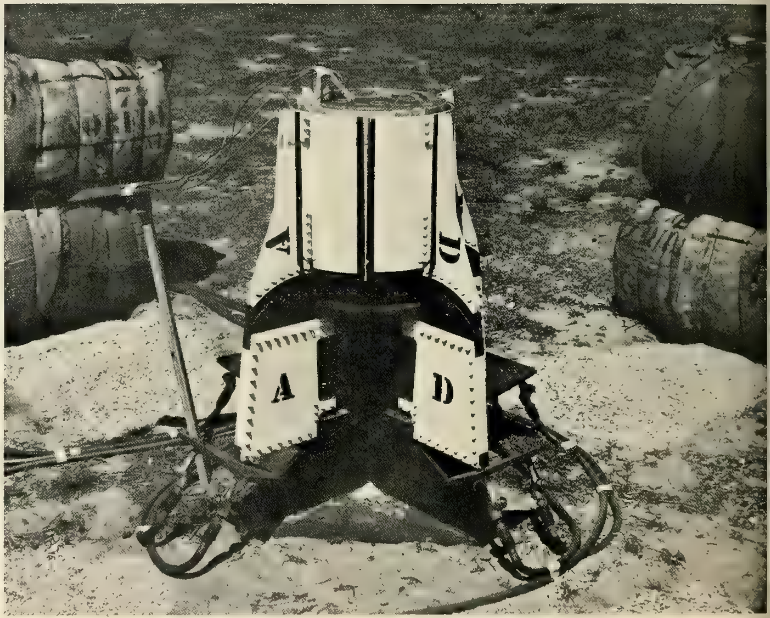
FLIGHT MECHANICS — Analyze guidance accuracy from tracking data. Apply analog and digital simulation techniques to general vehicle performance studies. Generate mathematical models of dynamic systems.

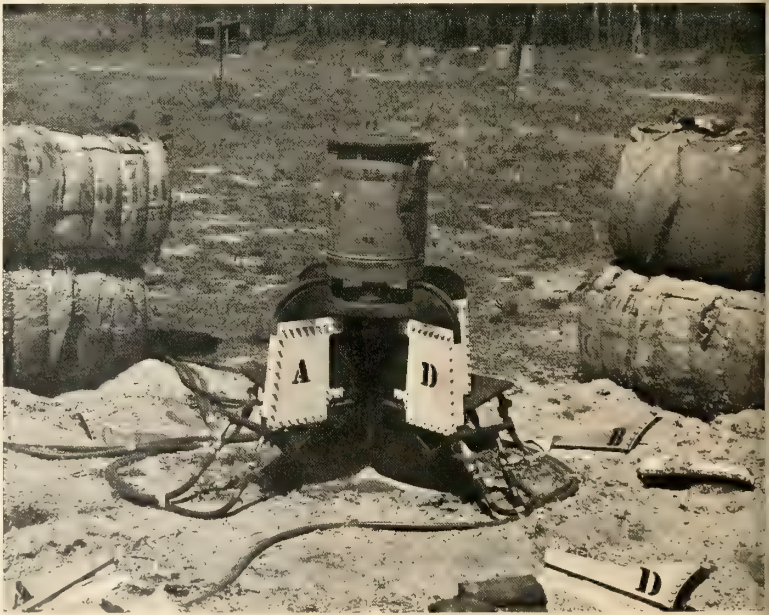
INQUIRIES ARE INVITED from those scientists and engineers who can make significant contributions to as well as benefit from, advances being made in all areas of Guidance & Controls. Write: Lockheed Missiles & Space Company, Dept. 530, P.O. Box A504, Sunnyvale, California.

LOCKHEED
MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

An equal opportunity employer

Explosive Structure Re
Designers of Air-to-





May Aid issiles

by Michael Getler

Bethpage, L.I., N.Y.—Explosive structure-removing techniques may be used to make certain types of air-to-air missile warheads more compatible with their airframe configurations—thus allowing more flexibility to designers of future missile systems.

This is the view of engineers here at the Grumman Aircraft Engineering Corp., where the concept has been under study since the 1950's.

Utilization of explosive methods to accomplish a large amount of mechanical work in a very short time and in confined spaces is not a new art, but it is relatively new with respect to space and defense programs. In recent months it has been winning wider acceptance in these fields; the F-111 crew-ejection capsule, for example, will call for extensive use of this technology.

Grumman's work received its major emphasis in 1959, under the Navy's now-cancelled *Eagle* air-to-air missile program. Grumman was the major airframe subcontractor to Bendix Corp., *Eagle* prime.

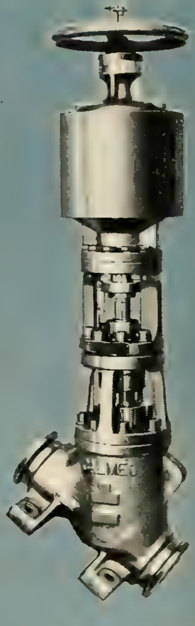
After *Eagle* was dropped in 1961, the explosive techniques Grumman was evolving for possible use in the project were judged significant enough to warrant two more years of advanced development effort, supported by Dept. of Defense and the company itself.

In May, 1963, Grumman reports, the technique was successfully demon-

BEFORE AND AFTER photos on opposite page show structural areas that would be removed by controlled explosives. In top photo, upper portion of test rig (white), with black stripes outlining quadrants, indicates portion of missile airframe that would encircle warhead. Top portions (A&B) represent wing parts also mounted over warhead. Bottom A&B sections represent aft wing portion that remains attached to the missile. Curved piece between two wing sections shows track on which wing section would ride clear of missile. Bottom photo shows exposed dummy warhead after surrounding airframe and wing sections have been blown off by exploding techniques.

10,000 PSIG Y-Globe Valves for high flow requirements

A series of Y-globe valves for 10,000 PSIG working pressure operate with flow coefficients approaching those of gate valves. At 10,000 PSIG operating pressure, less than 35 PSIG cylinder pressure actuates the valves; less than 160 in.-lbs. handwheel torque opens and closes the valves within 12 revolutions maximum.

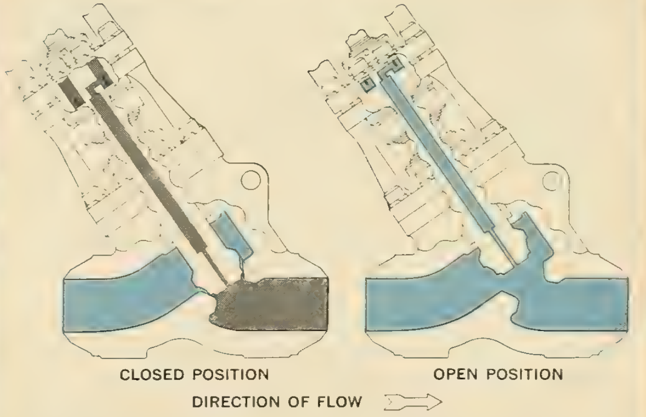


To assure smooth control in severe high-pressure applications, a compensating pressure disc assembly facilitates fast, cushioned stroking when opening and closing the valve with high differential pressures and velocities across the valve port.

CPD series valves are available in cylinder operated, manual operated and cylinder operated with auxiliary handwheel configurations in sizes from 1½" through 8" for operation over a temperature range of −452°F to +750°F.

Write for 8-page brochure describing operation and specifications.

COMPENSATING PRESSURE DISC OPERATION



Calmec compensating pressure disc assembly overcomes severe high pressure control problems by eliminating undesired line pressure forces acting against the valve stem and against both upstream and downstream sides of the internal valve plug. Equilibrating pressure on the valve plug and piston provides a cushioning effect and assures smooth stroking of the valve.

PATENTS PENDING

CALMEC

CALMEC MANUFACTURING CORP.
5825 District Boulevard • Los Angeles 22, Calif. • (213) 588-6204 • TWX (213) 773-5796

Circle No. 13 on Subscriber Service Card

SYSTEMS MEN NEEDED NOW IN FIVE VITAL WORK AREAS...

MITRE needs engineers and scientists who are interested in working on such projects as the NORAD Combat Operations Center, STRICOM's Command & Control System, Nuclear Detonation Detection & Reporting System, Range Instrumentation, and the National Military Command System.

We are looking for men who are systems oriented and who want to further broaden their interdisciplinary skills working on projects wholly in the national interest.

Immediate openings are available in Bedford, Massachusetts; Washington, D. C.; and Colorado Springs, Colorado, in the following work areas:

COMMUNICATIONS — Men with broad communications experience for work on the engineering of communication networks, range instrumentation, tactical air control, and survivable communications.

NUCLEAR WEAPONS EFFECTS ANALYSIS — Men with 2-4 years experience in the analysis of environmental effects of nuclear bursts on equipment, nuclear cloud obscuration problems and combinations of natural and nuclear effects on system performance.

SENSOR SYSTEMS & TECHNIQUES — Men needed to support theoretical and experimental programs on advanced radar and optical detection and tracking systems. Work includes feasibility and techniques analysis, systems synthesis and performance evaluation.

NATIONAL MILITARY COMMAND SYSTEM — Men for systems analysis and feasibility studies, communications systems analysis, systems design, integration, and design verification.

COMPUTER PROGRAMMING TECHNIQUES — Men with experience in specific fields, such as operations research, communications system analysis, computer software or hardware approaches, development and support of monitors, compilers, real time simulations, time sharing systems, etc.

If you have three or more years' experience and a degree in electronics, mathematics or physics, contact MITRE. Write in confidence to Vice President — Technical Operations, The MITRE Corporation, Box 208G, Bedford, Mass.

THE MITRE CORPORATION

An Equal Opportunity Employer

Pioneer in the design and development of command and control systems, MITRE was chartered in 1958 to serve only the United States Government. An independent nonprofit corporation, MITRE is technical advisor and systems engineer for the Electronic Systems Division of the Air Force Systems Command, and also serves the Department of Defense, and the Federal Aviation Agency.

Circle No. 14 on Subscriber Service Card

strated in a controlled test firing at the firm's Peconic, L.I., facility, using a dummy warhead. The warhead was later inspected visually and radiographically by the Navy, and reportedly showed no damage due to effects of the structure-removing explosives.

- **Complications**—The Grumman system basically involves a network of precisely timed and shaped explosive charges to remove sections of the missile's wings and airframe just prior to warhead detonation.

Since the 1963 test, no further work has taken place. Engineers here feel that in terms of ground engineering they have gone about as far as they can. Despite the fact that the program has been dormant for the past two years, however, they remain confident that the methodology holds a valid promise of added flexibility for designers of future systems.

The system's usefulness, they say, should be judged in the light of all of the requirements, sometimes conflicting, which make themselves felt while a single missile design is evolving.

For example, future air-to-air missiles aimed at countering high-performance targets with conventional warheads having relatively small miss-distances will make increasing demands upon the missile's control system and the amount of control surface area needed to respond to guidance commands.

Since the warhead section generally is located somewhere between the missile's target seeker and propulsion unit, increasing the wing area of the missile can place control surface structure directly over the warhead-housing area on the missile. This can complicate the lateral firing of certain types of conventional high-lethality warheads, such as the continuous-rod variety, requiring some scheme to remove the structural impedance to the warhead.

(A continuous-rod warhead generally involves a thin rod of metal, much like an expansion watch band, which encircles a high explosive. When the explosive ignites, it causes this ring to expand at great speeds and move at very high velocities towards the target region. Disturbing either the explosive before it detonates or the metal ring as it passes beyond the missile shell could reduce the effectiveness.)

The control surface problem can also arise if limitations are placed upon the distance from the frame that the wing areas can extend. If there are such limitations—based possibly upon logistics and handling considerations, or aerodynamic interference with the carrying aircraft—the alternative again may be to add the necessary wing area by moving longitudinally along the airframe.

Another problem is that control surfaces for highly maneuverable missiles must be retained until the last possible moment in attacks against high-performance targets, where closing speeds possibly in excess of Mach 4 may be encountered.

- **Possible solution**—It is for this potential combination of requirements that Grumman engineers see a workable solution in the explosive method they have evolved.

This technique involves use of explosive circuitry and charges to first perforate the main airframe structure which is to be removed, and then actually blow off that structure and that portion of the wing section which is attached to it. This must be done in such a way as to direct the removed structure aft, so that it will not interfere with the exploding warhead material.

Sequence timing would be keyed to the initiation of warhead fuzing, which means that the entire operation must be carried out in a matter of milliseconds prior to warhead detonation. More important, the structure-removing blasts must neither damage the warhead in any way or detonate it prematurely.

The system works off a conventional igniter using mild detonating cords of different lengths to connect to both the skin-cutting and structure-removing charges. The lengths of these cords are very critical to the timing involved. The structure circling the warhead section is removed in quadrants, simultaneously, leaving the warhead completely exposed for a split second before it explodes.

Placing of the explosives and selection of the types used must be carefully matched to the physics of the problem, Grumman engineers point out. For example, a 1/16-in.-thick steel missile structure might yield in an undesirable fashion. Engineers have used chemically milled materials to maintain the desired stiffness at certain points.

Another problem in developing these techniques was a lack of instrumentation capable of operating and accurately reporting data in the presence of the very high pressures and rapid rise times of some of the explosive charges used. As a result, Grumman engineers say the development was largely an empirical procedure.

- **Perforating**—For the skin perforation, Grumman uses a linear-shaped charge, provided by the Ensign-Bickford Co. in Connecticut, which is run along the interior of the airframe for the length of the warhead section and then around the circumference of the airframe in rings. The charge uses military explosives of a higher power than TNT.

The action is described as a "supersonic zipper" by Grumman engineers. The charge moves at speeds of 25,000 fps and is started at multiple points so that the entire perforation procedure takes only microseconds.

This procedure, on which previous development had taken place, was actually tailored for missile use in the advanced development effort. However, the test in 1963 was made with a missile with pre-cut skin, testing basically the wing removal portion and the warhead protection capabilities.

- **Removal**—The problem of removing the structure once it is perforated involves shaping the charge so that the entire wing segment moves at the same time—and in its proper mass relationship and direction.

To solve this, Grumman developed both a specifically shaped charge and a mechanical track which the wing segment rides during ejection to insure proper guidance into the airstream.

The design which evolved uses a Dupont explosive (EL-506F) in the form of a semi-flexible rolled sheet material made into a multilayer compound and shaped in a trapezoid in order to get the desired spreading of the energy.

When the wing charge is ignited, the wing and missile frame moves out of the way, using the track system; Grumman engineers consider this development a major advance in missile design.

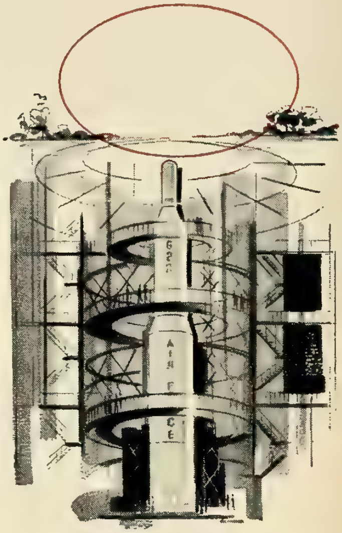
The track consists of two parts: a fixed track curves outboard and is permanently attached to the aft portion of the wing, that part of the wing which remains attached to the missile; the other half of the system is a set of "slippers" which fit over the fixed track. Both sections are treated with a solid lubricant to avoid binding them during the ejection. Grumman says the technique has functioned perfectly in numerous tests.

- **Shielding**—Protection of the warhead, according to Grumman, was mostly a problem of shock and blast and was not one of high-temperature effects of the explosion. This was true primarily because of the thermal lag qualities of steel and other structural materials.

The protective material also had to be of low mass, so that warhead material could pass through it after detonation without decreasing effectiveness. Engineers experimented with different foaming-type plastics, and settled on a rigid foamed plastic made up of fairly dense individual cells that break down under shock loading and absorb the ejection blast.

Engineers here report that cross-grain wood also is feasible for the protective role, exhibiting good absorption and break-up capabilities. However, plastics are considered to be far superior in terms of controlling the quality of the material. ■

UNDERGROUND
CORROSION
PROBLEMS?



Moisture and condensation causing corrosion problems on steel railings, stairs, diamond plate decking? Rust-Oleum research has developed *specialized* coatings to help you solve these problems. Rust-Oleum specialists are available to work hand-in-hand with you and your organization. May we hear from you?

RUST-OLEUM CORPORATION
2477 Oakton Street · Evanston, Illinois, U.S.A.
and
Rust-Oleum (Nederland) N.V.
Haarlem, The Netherlands

Over forty years of industry proof. Distinctive as your own fingerprint.

RUST-OLEUM®
STOPS RUST!®

Circle No. 15 on Subscriber Service Card

NEW

INSTRUMENTATION TELEVISION CAMERA

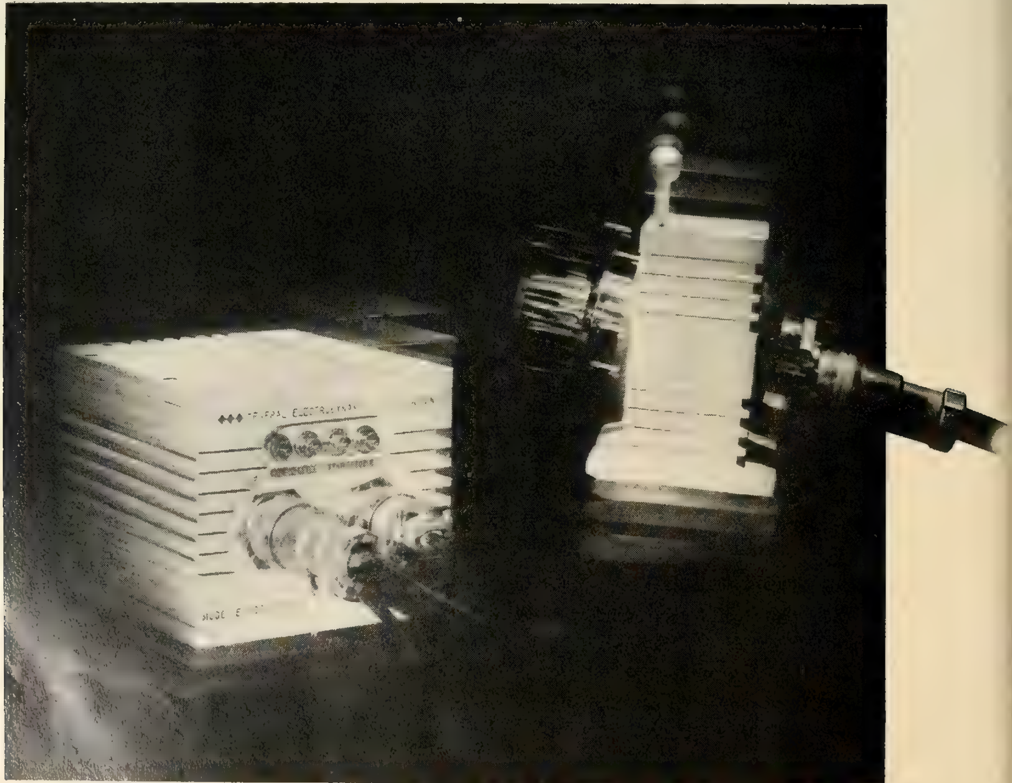
OPERATES IN EXTREME ENVIRONMENTS

The ED 6038 miniaturized instrumentation television camera was designed by General Electrodynamics Corporation to operate in the extreme environment existing within the engine compartment of the largest space boosters, such as Saturn. The high quality pictures produced during this severe environment will provide direct, real-time observation of events while they are happening.

This compact, light weight camera is available in a number of configurations with a wide selection of accessories from General Electrodynamics.

ENVIRONMENTAL CHARACTERISTICS:

20g RMS
60g RMS for 5 sec
20 cps — 2000 cps random
Shock: 100g for 11 ms
Altitude: Space environment
Acoustical Noise: +175 db
Temperature: —10°C to +71°C operating
—10°C to +125°C non-operating
Explosion Proof



GENERAL ELECTRODYNAMICS CORPORATION

4430 FOREST LANE • GARLAND, TEXAS • BROADWAY 6-1161

Circle No. 16 on Subscriber Service Card

The Industry Week

Mergers and Acquisitions

Electro-Optical Systems, Inc., Pasadena, Calif., has agreed to purchase Applied Optics and Mechanics, Inc., of Arcadia, Calif., for an undisclosed amount of cash. Negotiations are presently under way and a final decision is expected by the end of April. As presently planned, AOM will become a subsidairy of EOS. AOM designs, develops, and fabricates systems and components for aerospace, military and commercial applications. . . . *Milgo Electronic Corp. of Miami has announced that it has acquired Control Technology, Inc., Long Beach, Calif., a firm engaged in computer application technology. Milgo designs and fabricates general and special purpose analog computing equipment as well as a wide range of data handling equipment.* . . . Stromberg-Carlson Corp., San Diego, Calif., has agreed to purchase the business and assets of Information Products Corp. of South Hadley, Mass. IPC makes a family of electronic data input-output systems incorporating display devices for use with computerized and other information storage systems. These products will be used to complement S-C's line of advanced electronic data handling and display systems. . . . *General Precision Equipment Corp., Tarrytown, N.Y., has acquired Tele-Signal Corp. of Hicksville, N.Y., a privately owned manufacturer of data communications equipment. The acquisition is viewed by GPE as expanding its product scope in electronics.* . . . Sprague Electric Co., North Adams, Mass., has acquired controlling interest in Micro Tech Mfg., Inc., of Sunnyvale, Calif., a manufacturer of semiconductor assembly equipment.

Firms Lauded for Gemini Work

Small Business Administrator Eugene P. Foley has cited McDonnell Aircraft Corp. board chairman J. S. McDonnell "for promoting the growth and welfare of hundreds of small firms through utilization of their facilities and skills in the production of America's first two-man spacecraft." Three other businessmen also received special aerospace awards from the SBA for their subcontract work on *Gemini:* Albert S. Kepen, president of Asto Metallics Corp., for his firm's work on the *Gemini* heat shield; Ralph E. Darling, Sr., president of R. E. Darling Co., for oxygen breathing hoses used by the astronauts; George A. Clark, president of Snap-Tite, Inc., for quick-disconnect couplings that joined the oxygen hose with the oxygen supply.

New Facilities

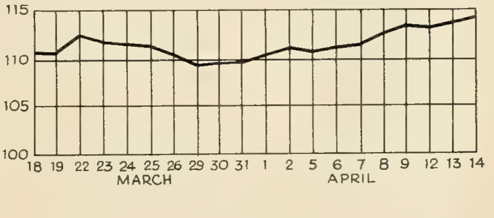
The Air Force is nearing completion of a $2.3-million environmental test facility at Edwards AFB, Calif. The facility will be used in studying adverse effects of space on rockets and advanced propellants and will be capable of handling vehicles of up to 16 ft. in diameter, 20 ft. in length and weighing more than 100,000 lbs. The chamber will also include a 7,500-sq.-ft. assembly building and a control and instrumentation building. Temperature range attainable in the facility will be −300° to 400°F and altitude simulation to 600,000 ft. will be possible. . . . *Air Reduction Co., Inc., New York, has purchased a 37-acre site at Mims Industrial Park near Titusville, Fla., on which it plans to build a liquid oxygen-nitrogen plant to serve NASA at Cape Kennedy.* . . . TRW Space Technology Laboratories, Redondo Beach, Calif., has expanded its San Bernardino, Calif., operation and renamed it Systems Engineering and Integration Program Management to better reflect "the changing nature of programs our San Bernardino operation is now managing." . . . *The Air Force Systems Command expects to complete a high vacuum test chamber it is constructing at Wright-Patterson AFB, Ohio, by September.*

Industry Considers Dulles Show

As plans for an American counterpart of the Paris Air Show begin to gain momentum, aerospace marketing, sales and advertising men are faced with a major decision—to exhibit or not to exhibit. With the blessings of President Johnson and FAA Administrator Halaby and the qualified support of the Aerospace Industries Assoc., the show is tentatively scheduled for a 10-day run in mid-June or -September, 1966, at Washington's Dulles Airport. Its aim would be to expand foreign markets for U.S. aviation, space and related products. The question is whether the business that might be stimulated by an untested show is worth the $25,000 to $100,000 cost of exhibiting equipment.

Missile/Space Stock Index

Defense stocks underwent a surge of activity following several announcements from Government and industry. Boeing made a large jump following a United Airlines decision to buy $750 million worth of jet planes, primarily from Boeing. The announcement caused a drop in Douglas Aircraft stock. General Dynamics, Grumman and United Aircraft stock rose following formal announcement of the impending sale of TFX aircraft, worth about $1 billion, to Great Britain. President Johnson's declaration that the U.S. will step up military support to Viet Nam also increased defense stock activity.



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

contracts and procurements

AWARDS

AIR FORCE

$40,000,000—**General Dynamics Corp.**, San Diego, Calif., for 28 standardized *Atlas* space launch vehicles (SLV-3X) and associated effort during 1966 and 1967.

$13,000,000—**Douglas Aircraft Co., Inc.**, Missile and Space Systems Div., Santa Monica, Calif., for 28 *Thor* space boosters.

$4,000,000—**General Telephone and Electronics Corp.**, Sylvania Electric Products, Inc., New York City, to install hardened underground antennas at 165 *Minuteman* missile sites in North Dakota.

$2,500,000—**Radio Corp. of America**, Missile and Surface Radar Div., Moorestown, N.J., for the BMEWS program.

$2,500,000—**Radio Corp. of America**, Missile and Surface Radar Div., Moorestown, N.J., contract increase for undisclosed program.

$1,363,532—**United Electrodynamics, Inc.**, Alexandria, Va., for work on a classified project.

$1,125,000—**Dow Chemical Co.**, Midland, Mich., for development and evaluation of advanced solid propellants.

$613,277—**Ets-Hoskin Corp.**, Wilmington, Calif., for container sets for *Sparrow III* missiles.

$350,000—**IIT Research Institute**, Chicago, for a nondestructive testing system of residual machinery stresses for analysis and control.

$135,000—**Radio Corp. of America**, Missile and Surface Radar Div., Moorestown, N.J., for spares for the AN/FPS Moorestown Tracking Radar Test Facility.

$95,250—**IIT Research Institute**, Chicago, for analysis of optical wave front distortions caused by the atmosphere.

$54,040—**Laboratory For Electronics, Inc.**, Electronics Div., Boston, for research in ferromagnetic thin films.

$20,618—**IIT Research Institute**, Chicago, for theorem proving by computer.

ARMY

$4,000,000—**Western Electric Co.**, New York City, for radar research and development work on Kwajalein in connection with *Nike-X*.

$1,885,250—**General Electric Co.**, Schenectady, N.Y., to manufacture a new 6,000-shot-per-minute weapon system for the Air Force.

$788,000—**Rohm and Haas Co.**, Huntsville, Ala., for continued research on high-energy propellants at Redstone Arsenal.

$162,000—**Martin Co.**, Orlando Div., Orlando, Fla., for an analysis of the nation's air defense network.

$90,000—**Hughes Aircraft Co.**, Culver City, Calif., for a 12-month research program for development of a tripod tracking aid.

$61,057—**Thiokol Chemical Corp.**, Huntsville Div., Huntsville, Ala., for additional engineering services and design of components for the *DC-MAW* missile system.

$52,369—**Philco Corp.**, Newport Beach, Calif., for modulators and supporting repair parts for *Shillelagh* research and development.

NAVY

$8,715,062—**Litton Systems, Inc.**, Woodland Hills, Calif., for inertial navigation systems.

$7,323,000—**Northrop Corp.**, Nortronics Div., Palos Verdes, Calif., for development and production of automatic test and checkout systems aboard 1052 Class ASW destroyer escorts, designated TEAMS (Test Evaluation and Monitoring Systems).

$6,500,000—**General Electric Co.**, Syracuse, N.Y., to make sonar-modification kits.

$2,800,000—**Hughes Aircraft Co., Inc.**, Culver City, Calif., for continued work on the *Phoenix* air-to-air missile.

$2,336,221—**General Electric Co.**, Pittsfield, Mass., for *Polaris* missile fire-control system.

$1,000,000—**General Precision, Inc.**, Wayne, N.J., for research and development on airborne gyrocompasses.

NASA

$175,125,000—**International Business Machines Corp.**, Federal Systems Div., Rockville, Md., for integration and checkout of instrument units for *Saturn IB* and *V*

$76,300,000—**Douglas Aircraft Co., Inc.**, Missile and Space Systems Div., Santa Monica, Calif., for eight additional *Saturn* S-IVB rocket stages.

$8,000,000—**Grumman Aircraft Engineering Corp.**, Bethpage, N.Y., to construct a prototype of an unmanned orbiting astronomical observatory.

$4,587,400—**Radio Corp. of America**, Missile and Surface Radar Div., Moorestown, N.J., for AN/FPQ-6 Tracking Radar for installation in Bermuda.

$1,397,000—**Dortech, Inc.**, Stamford, Conn., for building three *Saturn V* booster ground transporters.

$1,307,347—**Space Corp.**, Garland, Tex., for fabrication, testing, assembly installation and checkout of the servicing platforms to be used in the Vehicle Assembly building mobile launchers and pad 39A at Cape Kennedy.

$348,937—**F. B. MacLaren and Co.**, Huntington Station, N.Y., for a spacecraft docking simulator.

$100,000—**Radio Corp. of America**, Missile and Surface Radar Div., Moorestown, N.J., for spare parts for the *Apollo* program.

$100,000—**TRW/Space Technology Laboratories**, Redondo Beach, Calif., for a feasibility analysis of the TRW/STL direct flow gas core propulsion system.

$74,800—**TRW/Space Technology Laboratories**, Cleveland, for a study to optimize high power static inverters.

Westinghouse Electric Corp., Baltimore, to provide one of the experimental packages aboard a satellite that will pave the way for future unmanned orbital laboratories (amount not disclosed).

Gordon and Breach Science Publishers, New York City, for publishing the forthcoming NASA book entitled *An Introduction to Space Science* (amount not disclosed).

INDUSTRY

$11,030,724—**Texas Instruments, Inc.**, Dallas, from **North American Aviation, Inc.**, Autonetics Div., Anaheim, Calif., for guidance, digital computers, flight control and ground equipment in connection with *Minuteman II*.

What's the shortest distance between these 2 points?

Los Angeles ✱ San Diego • Houston • New Orleans • Melbourne ✱ **Cape Kennedy**

National's direct line.

We call it our "Rocket Run." It's the only direct jet service between the major space centers of the west and Melbourne (closest airport to Cape Kennedy.)

You jet between Los Angeles and Melbourne without changing planes. National also serves the key space age cities along the east coast.

Is this any way to run an airline? You bet it is.

Jet National
coast to coast to coast

Circle No. 17 on Subscriber Service Card

$3,787,900—**Westinghouse Electric Co.**, Compton, Calif., from **North American Aviation, Inc.**, Autonetics Div., Anaheim, Calif., for guidance, digital computers, flight control and ground equipment for *Minuteman II*.

$2,300,000—**The Bendix Corp.**, Detroit, from **The Boeing Co.**, Seattle, for modification of emplacement systems for *Minuteman* missile.

$1,300,920—**Radio Corp. of America**, New York City, from **North American Aviation, Inc.**, Autonetics Div., Anaheim, Calif., for *Minuteman II* guidance digital computers, flight control and ground equipment.

$1,000,000—**Erie Forge and Steel Corp.**, Erie, Pa., from **Allied-Shafer**, Los Angeles, to supply parts for the launching of the *Saturn V* rocket.

$700,000—**Radio Corp. of America**, Missile and Surface Radar Div., Moorestown, N.J., from **Massachusetts Institute of Technology**, Cambridge, Mass., for a classified program.

$600,000—**Electronic Specialty Co.**, Electronics Div., Portland, Ore., from the **Magnavox Co.**, Ft. Wayne, Ind., for crystal can relays.

$500,000—**Battelle Memorial Institute**, Columbus, Ohio, from industrial firms in the U.S., Germany, France and Japan for continuing research of chemical vapor deposition.

$300,000—**Quantic Industries**, Pelmec Div., San Carlos, Calif., from **North American Aviation, Inc.**, Space and Information Systems Div., Downey, Calif., for the design and manufacture of explosively operated valves and cartridges for NASA's *Apollo* spacecraft program.

$300,000—**Talley Industries, Inc.**, Mesa, Ariz., from **The Boeing Co.**, Seattle, to supply actuating devices for the *Minuteman* missile launcher facilities.

$292,000—**Scientific Data Systems**, Santa Monica, Calif., from **Hughes Aircraft Co.**, Culver City, Calif., for an SDS 930 computer system.

$153,042—**General Electric Co.**, Syracuse, N.Y., from **North American Aviation, Inc.**, Autonetics Div., Anaheim, Calif., for *Minuteman II* guidance, digital computers, flight control and ground equipment.

$100,000—**Space Corp.**, Dallas, from **The Boeing Co.**, Seattle, for work on the *Minuteman* program.

Bjorksten Research Laboratories, Inc., Houston, from **Crysler Corp.**, Chemical Div., for research of special materials (amount not disclosed).

Planning Research Corp., Los Angeles, from **Stanford Research Institute**, Menlo Park, Calif., for further development of a computerized war game, CARAMBA (Computer-Assisted Rapid Air and Missile Battle Analysis Game) (amount not disclosed).

DEPARTMENT OF DEFENSE

$4,300,000—**Illinois Institute of Technology**, Research Institute, Chicago, for the continued technical management of the Electromagnetic Compatibility Analysis Center at Anapolis, Md.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

National Institutes of Health
Supply Management Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama

RFQ due date May 10, 1965, for the design, fabrication, evaluation and delivery of a bi-directional spectroreflectometer. RFQ 1-5-01064.

National Aeronautics and Space Administration
Goddard Space Flight Center
Glendale Road
Greenbelt, Maryland 20771
Contracting Officer—Code 246

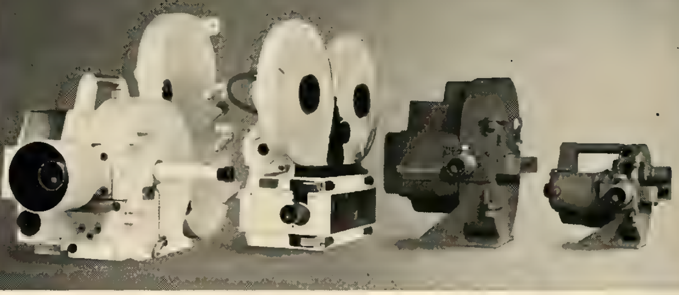
RFP 636-38753-164 due May 7, 1965, to design, develop and fabricate a solar simulator for laboratory use.

WONDERING WHICH HIGH SPEED CAMERA TO BUY? ONLY WOLLENSAK FASTAX CAMERAS GIVE YOU...

• Highest resolution • Greatest versatility • Most durability • Highest speed ranges . . . 150 to 18,000 pps • Proven reliability • Most models . . . 30 cameras . . . 8, 16, 35mm Motion picture, oscillo-streak or combination

If you WANT THE BEST you'll select WOLLENSAK FASTAX . . . time tested for over 15 years!

3M COMPANY



WONDERING IF HIGH SPEED PHOTOGRAPHY CAN HELP SOLVE YOUR DESIGN . . . ENGINEERING PROBLEMS

THEN see our new, colorful motion picture film "FASTAX-TION." It shows all. CONTACT our representative in your territory:

Alpha Photo Prods., Inc.
1101 Grove St.
Oakland, Calif. 95607

Brook-Anco Corp.
75 College Ave.
Rochester, N. Y. 14607

Garrick Photo Supply
3166 Cass Ave.
Detroit, Mich. 48201

Claus Gelotte Camera Stores
185 Alewife Brook Parkway
Cambridge, Mass. (38)

Gordon Enterprises
5362 N. Cahuenga Blvd.
N. Hollywood, Calif. 91601

Paul Ziarnowski
23253 Ivan Ave
Cleveland, Ohio 44123

Maher Engineering Co.
13 Broadway
Des Plaines, Ill. 60016

Jack Kronemyer
845 North Hampton Drive
Silver Springs, Md.

Photo Sciences Div.
Fotomart, Inc.
44 N. 9th St.
Philadelphia, Pa. 19107

Southwestern Engineering and Equipment Company
6300 N. Central Expressway
Suite No. 105
Dallas, Texas 75206

Stanley Photo Service
2838 Market St.
St. Louis, Missouri 63103

or call Photographic Equipment & Optical Division, 3M Company
701 Hudson Avenue
Rochester, N. Y. 14621

Circle No. 18 on Subscriber Service Card

IVA

1st World Exhibition of Transportation and Communication

Munich, Germany
June 25—October 3

The latest wonders in the world of Space Travel • space stations • satellites • air travel • electronics

Assistance in your travels, tickets:

German American Chamber of Commerce, New York: 666 Fifth Avenue • Chicago: 77 E. Monroe Street or German Tourist Information Office, New York: 500 Fifth Ave., also Chicago, San Francisco, Montreal

Circle No. 19 on Subscriber Service Card

let us move with you!

Six Weeks Is Required To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, if possible, the address label from your last issue . . . include your postal ZIP number. Thank you.

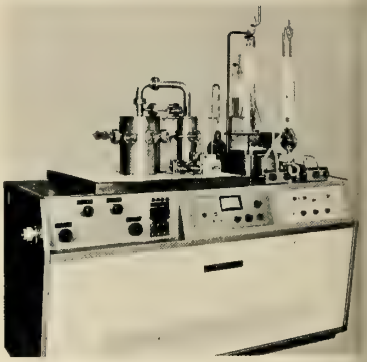
Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

New Product of the Week: Vacuum Gauge Calibrator

A system capable of calibrating up to seven vacuum gauges simultaneously at a pressure range from 1 x 10^{-1} to 5 x 10^{-7} torr is being marketed by Vacuum Industries, Inc.

The "Calivac 100" utilizes both direct McLeod gauge comparison and orifice flow pressure reduction techniques to perform extended range vacuum calibration. Calibration is accomplished by comparing the gauge indication with that of either a high or low-range precision McLeod gauge. A series of calibrated orifices (utilizing the principle of a known pressure drop across the orifices) and a trapped diffusion pump are used to extend the calibration range beyond that at which accurate McLeod gauge readings can be taken.



The ranges of the McLeod gauge and orifice method overlap so that accurate measurements can be made over the range of 1 x 10^{-9} torr. Pumping system and manifolding are constructed of 304 stainless steel as is the calibration chamber which can be evacuated to 1 x 10^{-10} torr. The bakeout oven is capable of baking the calibration chamber with gauges attached to controlled temperatures up to 450°C.

Circle No. 151 on Subscriber Service Card

AM Command Receiver

A VHF AM receiver for use in the 150-mc command band has been developed by RS Electronics.

The Model 4787 is an all-silicon, crystal-controlled unit with a 0.5 μv sensitivity for 6 db $\frac{S+N}{N}$ ratio when modulated 50% (5 μv for 20 db $\frac{S+N}{N}$). The unit has an IF bandwidth of 45 kc at the 6-db points and 100 kc at the 60-db points. Audio output is 1v ac RMS into 5,600 ohms with 90% modulation. Audio bandwidth is 500 cps to 12.5 kc. Image and spurious rejection is 60 db. Input is 180 mv; operating temperature range is − 65° to 72°C.

Circle No. 152 on Subscriber Service Card

AC/DC Kilovoltmeters

Peschel Instruments, Inc., is marketing a line of portable triple-range ac/dc kilovoltmeters. The units are available in three ranges: 0-5/10/25 kv, 0-10/25/50 kv and 0-25/50/100 kv.

The units measure 5.5 x 7 x 3 in. and weigh 2 lbs. Probes accompanying the models are 9, 15.5 and 28.5 in. long. Kilovolt values may be read on the 4-in. scale. Meter accuracy is ± 2% (dc) or ± 3% (ac) full scale. The instruments offer a maximum circuit loading of less than 100 μa.

Circle No. 153 on Subscriber Service Card

Booster Amplifier

Pastoriza Electronics, Inc., is marketing a booster amplifier, the Model BA 100-1000, for use with operational and differential amplifiers.

The unit will deliver ±100v at 1 ampere from dc to 2,000 cps. It has its own power supply for operation directly from 60-cycle power. Space for an input amplifier and network are provided on the same chassis.

Circle No. 154 on Subscriber Service Card

Data Generator

A data generator which provides six channels of serially programmed pulse outputs in NRZ or RZ (variable width) format is being marketed by Datapulse, Inc.

The Model 206M offers 72 bits per channel and independent delay, width and amplitude for each channel. Internal clock rate is continuously variable from 2 cps to 2 mc. Provision is made to slave the unit to an external signal source and a single clock may be generated for each operation. Tenth content of each bit in each channel may be independently toggle-switch programmed. Serial word length is selectable from 1 to 100 serial bits.

Sync output is positive 6-v pulse, approximately 50 nanosec. wide with 100 ohms source impedance.

Circle No. 155 on Subscriber Service Card

NASA'S NEW ELECTRONICS RESEARCH CENTER

A SPECIAL REPORT...

...to be published in MISSILES AND ROCKETS May 31, 1965 issue. The new center, although just entering the construction phase, has already issued RFP's to industry for electronics research contracts. The center which will eventually direct 50% of NASA's electronics research, has a FY '66 budget which already has reached $22 million, and by 1969 should reach $100 million.

More important, the Electronics Research Center will be in the forefront of NASA's drive to achieve the state-of-the-art advances in electronic systems and components required to carry out the sophisticated space missions planned in the late sixties and through the next two decades.

This report will provide in-depth analyses of Electronics Research Center's plans and programs, procurement policies, responsibility in electronic research and the construction schedule, costs and equipment for the individual laboratories.

For companies marketing to NASA, this report offers a unique opportunity to reach the heart of the buying influences. Plan now to capitalize on this outstanding advertising opportunity.

Bonus Circulation: This issue of MISSILES AND ROCKETS will be delivered to every engineer, every designer, every scientist, and every management man at the Electronics Research Center. Copies will be made available to other Electronic Centers of NASA.

PUBLISHED: MAY 31 **ADVERTISING CLOSES: MAY 17**

missiles and rockets

the weekly of advanced technology

.09
.08
.07
.06
.05
.04
.03
.02
.01
SUCCESS!

POSEIDON!

When designing missile hardware that must withstand extremely high temperatures ... whether rocket nozzle inserts, nose cones, leading edges, or hot gas valves ... be sure to measure your requirements against the proven capabilities of tungsten and molybdenum.

Pure tungsten and molybdenum from General Electric have played key roles in the success of the Minuteman and Polaris and can make major contributions to the success of your design. The nozzle inserts in all stages of Minuteman II are machined from pure tungsten forgings.

Excellent resistance to erosion, corrosion, and thermal fracture are primary reasons for the use of tungsten nozzle inserts. Process development work by the forging industry has significantly lowered the ductile-brittle transition temperature of tungsten forgings—greatly improving resistance to thermal shock.

Forged tungsten is a tested and proven material. Thousands of intricate parts have been machined from it to close dimensional tolerances. The mirror finish now possible on tungsten parts is only one indication of the tremendous improvements that have been made in machining techniques.

For more information on tungsten or molybdenum, write or call: General Electric Co., Lamp Metals and Components Dept., 21800 Tungsten Rd., Cleveland, Ohio 44117. Tel: (216) 266-3145.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle No. 20 on Subscriber Service Card

names in the news

NEWTON

WU

BINGER

Charles T. Newton: Resigned as director of communications at General Dynamics/Convair to become president of the International Information Institute. The Institute will provide solutions to information problems in organizations.

William I. L. Wu: Appointed to the newly-created position of chief scientist for the Metrics Div. of Singer Co.

James H. Binger: Elected chairman of the board at Honeywell, Inc. He succeeds **Paul B. Wishart** who retired. **Stephen F. Keating** will become president in Binger's place.

Harold T. Luskin: Named to represent the American Institute of Aeronautics and Astronautics (AIAA) at the Sixteenth International Astronautical Conference in Athens in September. He is head of manned space programs at Lockheed Missiles & Space Co.

Norman Wade: Elected vice president of engineering at Dynasil Corp. of America. He was formerly with Goddard Space Flight Center where he was an environmental engineer.

Robert J. Monahan: Named special assistant to the president of The Mitre Corp. He will be succeeded by **Robert S. Soukup** as head of the technical program office.

Graydon Lloyd: Elected president of The Bristol Co., a subsidiary of American Chain & Cable Co., Inc. He succeeds **William H. Faeth** who retired last December.

Donald Zier: Joined Rocket Research Corp. as senior design specialist. He was formerly with Boeing Co. where he worked with mechanical design of aircraft, missiles and advanced space systems.

Ling-Temco-Vought, Inc. Aerospace Corp. recently promoted six veteran employes to vice presidents: **D. G. Gilmore,** vice president-operations, Vought Aeronautics Div.; **Sol Love,** program director, A-7A, Vought Aeronautics Div.; **R. F. Ringham,** director of engineering, Vought Aeronautics Div.; **C. L. Brunow,** *Lance* Program director, Michigan Div.; **Dr. W. J. Hesse,** SC-142A V/STOL program director, Vought Aeronautics Div.; and **J. J. Welch, Jr.,** director of product development, Astronautics Div. All will retain present positions.

David B. Smith and **Walter Powell:** Appointed board members of Auerbach Corp. Both men have been consultants to the corporation and will be retained in that capacity.

Alfred A. Hennings: Elected a vice president of ITT World Communications Inc.

Dr. W. F. Cartwright: Named assistant to Philco Corp.'s director of engineering and research for defense, space and industrial electronics.

Dr. George F. Sommer: Elected vice president of the International Div. of Link-Belt Co. **Roy E. Lambert** was elected vice president and general manager of Indianapolis Operations.

Robert E. Jackson: Appointed manager of the newly-formed Instruments Div. of Trans-Sonics, Inc.

when and where

April

International Conference on the Mechanics, Physics and Chemistry of Solid Propellants, sponsored by the Office of Naval Research and Purdue University, Purdue University, Lafayette, Ind., April 19-21.

Third National Biomedical Sciences Symposium, sponsored by the Instrument Society of America, Statler Hilton Hotel, Dallas, April 19-21.

International Conference on Modern Trends in Activation Analysis, sponsored by the International Atomic Energy Agency, U.S. Atomic Energy Commission and Texas A&M University, Activation Analysis Research Laboratory, College Station, Tex., April 19-22.

46th Annual Meeting of the American Geophysical Union, Washington, D.C., April 19-22.

Results from Recent Scientific Satellites, sponsored by Goddard Space Flight Center and the Planetary Sciences Section of AGU (a part of the AGU Annual Meeting), Washington, D.C., April 20-21.

Symposium on System Theory, sponsored by the Polytechnic Institute of Brooklyn, IEEE, Society for Industrial and Applied Mathematics, AFOSR, ONR, and the Army Research Office, New York City, April 20-22.

First International Conference on Physics of Solids at High Pressures, sponsored by AFOSR, Tucson, Ariz., April 20-22.

Southwestern Conference and Electronic Show, sponsored by the IEEE, Dallas Memorial Auditorium, Dallas, April 21-23.

The Propagation of Waves Across the Pacific; "a Problem in Radiative Transfer," lecture sponsored by Advanced Research Projects Agency, DOD, The Pentagon, Washington, D.C., April 21.

Third International Conference on Nonlinear Magnetics, sponsored by the IEEE, Sheraton-Park Hotel, Washington, D.C., April 21-23.

Symposium on Recent Optimization Techniques, sponsored by Carnegie Institute of Technology, Optical Society of America and IEEE, Carnegie Institute of Technology, Pittsburgh, April 21-23.

Sixth Symposium on Engineering Aspects of Magnetohydrodynamics, sponsored by the University of Pittsburgh and the Carnegie Institute of Technology, University of Pittsburgh, Pittsburgh, April 21-23.

Second Annual Meeting and Technical Conference of the Numerical Control Society, LaSalle Hotel, Chicago, April 21-23.

Support for Manned Flight Conference, sponsored by AIAA, Air Force Logistics Command and Advanced Systems Division, Biltmore Hotel, Dayton, Ohio, April 21-23.

National Convention of the Society of American Value Engineers, Statler-Hilton Hotel, Boston, April 21-23.

Institute of Environmental Sciences Annual Technical Meeting and Equipment Exposition, Sherman House, Chicago, April 21-23.

1965 London International Engineering Exhibition, sponsored by the London Chamber of Commerce, the British Mechanical Engineering Federation, and the British Electrical and Allied Manufacturers' Association, Olympia and Earls Court, London, April 21-30.

Annual Meeting of the Propulsion and Combustion Panel of the Advisory Group for Aeronautical Research and Development to the North Atlantic Treaty Organization (AGARD), "Advances in Chemical Rocket Propulsion," University of California, San Diego, April 22-25.

Second Annual USA/European Conference, meeting follows this route: Marriott Motor Hotel, Philadelphia, April 25-28; Cape Kennedy, Fla., April 29; and Goddard Space Flight Center, Washington, D.C., April 30.

Western States Spring Meeting of the Combustion Institute, Los Angeles, April 26-27.

Third Annual Seminar-in-Depth, sponsored by the SPIE and U.S. Naval Ordnance Test Station, Los Angeles International Hotel, Los Angeles, April 26-27.

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Paris, France—11 Rue Condorcet; TRU 15-39

Advertisers' Index

AMPEX CORP. 18
Agency—Cunningham & Walsh, Inc.

CALMEC MFG. CORP. 35
Agency—Schaeper Industrial Adv.

CBS LABORATORIES 26
Agency—Warren, Muller, Dolobowsky, Inc.

CHANDLER EVANS CONTROL SYSTEMS DIV. COLT IND. 48
Agency—G. F. Sweet & Co., Inc.

DATA CONTROL SYSTEMS, INC. 2
Agency—Martin K. Speckter Assoc., Inc.

DEFENSE ELECTRONICS, INC. 6
Agency—H. Durand Assoc.

GENERAL ELECTRIC, LAMP METALS & COMPONENTS DEPT. 44
Agency—Dix & Eaton, Inc.

GENERAL ELECTRIC CO., MISSILE & SPACE DIV., SPACECRAFT DEPT. 5
Agency—Deutsch & Shea, Inc.

GENERAL ELECTRODYNAMICS CORP. .. 38
Agency—Alexander, Mackenzie Adv.

GERMAN AMERICAN CHAMBER OF COMMERCE 42

LOCKHEED MISSILES & SPACE CO. 34
Agency—Hal Stebbins, Inc.

MCDONNELL AIRCRAFT CORP. 47
Agency—John Patrick Starrs, Inc.

MINNESOTA MINING & MFG. CO., MINCOM DIV. 25
Agency—Reach, McClinton & Co., Inc.

MINNESOTA MINING & MFG. CO., PHOTOGRAPHIC EQUIPMENT & OPTICS DIV. 41
Agency—Wolff Assoc., Inc.

MITRE CORP., THE 36
Agency—The Bresnick Co., Inc.

NATIONAL AIRLINES, INC. 40
Agency—Kenyon & Eckhardt, Inc.

NETWORKS ELECTRONIC CORP. 4
Agency—Allen, De St. Maurice & Scroggin, Inc.

RADIO CORP. OF AMERICA, MISSILE & SURFACE RADAR DIV. 33
Agency—Al Paul Lefton Co., Inc.

RAYMOND ENGINEERING LABORATORY, INC. 10
Agency—The F. W. Prelle Co.

RUST-OLEUM CORP. 37
Agency—D'Arcy Adv. Co.

SANGAMO ELECTRIC CO. 31
Agency—Winius-Brandon Co.

SPACE TECHNOLOGY LABS., A SUB. OF THOMPSON RAMO WOOLDRIDGE, INC. 8
Agency—Fuller & Smith & Ross, Inc.

UNITED TECHNOLOGY CENTER 11
Agency—Hoefer, Dieterich & Brown, Inc.

On the Use of Gas

IT IS TIME for the U.S. to stop playing ostrich on the subject of chemical and biological warfare. Chemical and biological agents, lethal and incapacitating, are being manufactured. They can be delivered by artillery, missiles, aircraft, submarines, spacecraft and other means. As just demonstrated in Viet Nam, they also can be used in limited warfare.

Yet the Dept. of Defense shrinks from the reality of these weapons. One would have thought it logical that both before and after the use of gas in Viet Nam, DOD would have stepped up its effort to educate the public on this method of warfare.

Such was not the case. There were some interviews granted prior to the use of riot-control agents against the Viet Cong. We carried an article on the subject last October (M/R, Oct. 5, p. 14) and a piece just last month (M/R, March 29, p. 58).

But the resultant worldwide uproar over the use of gas in Southeast Asia caught DOD and the State Department by surprise in a situation that could have been forecast by any political neophyte. The reaction of the Defense Dept. has been typical. Chemical and biological warfare now is a verboten subject. No interviews can be granted and military officials have been forbidden to discuss the topic. The article by Senior Editor William Beller on p. 27 of this issue already was in preparation when the storm broke with the Viet Nam disclosure. Scheduled visits to Edgewood Arsenal and Ft. Detrick, U.S. chemical and biological warfare centers, were canceled. A security curtain was lowered on all aspects of CBR (chemical, biological and radiological warfare).

The head-in-the-sand attitude toward these little-discussed agents is not new. The House Science and Astronautics Committee said in 1959:

"There is an urgent need for greater public understanding of the dangers and uses of CBR if proper support is to be given to our defenses and countermeasures."

Brig. Gen. J. H. Rothschild, retired commanding general, U.S. Army Chemical Corps Research and Development Command, said last year:

"These weapons often appear mysterious and sinister to the general public. I think that much of the responsibility for this feeling falls on our government which, by placing great restrictions on the public discussion of these weapons by military officers, has fostered this miasma of ignorance."

We agree with both of these statements. As a result of the use of gas in World War I, many persons still consider it as one of the most horrible weapons available. Yet today, in the wide range of CBR agents available and under development, there are some of the non-lethal type which are well suited for the type of limited warfare in Viet Nam.

It is interesting to note some figures from a book published last year by Gen. Rothschild (*Tomorrow's Weapons*, McGraw-Hill Book Co., 1964) in regard to use of gas in World War I. Of the 272,000 casualties suffered by the American Expeditionary Force, about 26.8 per cent resulted from gas, but only 2 per cent of these casualties died in contrast to the 25.8 per cent of the other, non-gas, casualties. Furthermore, reports Gen. Rothschild, men who were gassed suffered proportionately fewer lasting effects than those wounded by shellfire.

We are not trying to make a case here for the use of gas in Viet Nam or anywhere else, but we think such figures as these do illustrate that there is a great deal about the use of gas which should be open to public discussion.

The panic exhibited by the Dept. of Defense in the face of the Viet Nam disclosures hardly contributes to the calm and rational discussion of the issues involved, which is so much needed. The riot-control agents sent to Saigon were of three types: ordinary tear gas, an improved version called super-tear gas, and a vomiting agent known as adamsite.

Their use against the Viet Cong seems an excellent idea from a military standpoint. The fact that they were largely unsuccessful and the fact that they were used by Vietnamese and not U.S. forces has little to do with the military logic of the situation—although the Pentagon and State Dept. seem to feel that these facts largely absolve the U.S. of any role in the matter. The truth is that DOD and State should have been prepared to defend the action and that preparation for better public understanding should have been undertaken years ago.

THE USE of incapacitating agents is particularly effective in a counter-guerrilla action such as Viet Nam, where the enemy frequently mingles with the civilian population. The ideal agent for such action was described by Dr. Chalmers W. Sherwin of the Directorate of Defense Research and Engineering (M/R, Oct. 5, p. 14):

"The goal is to make a man militarily useless in a controlled manner with an agent which will act in seconds and have an effect lasting from several hours to several days." The anaesthetic effect of such an agent would literally leave the enemy unconscious.

The ideal agent for this apparently has not yet been found but there are several that approach this description. Offered a choice of being sprayed with this or with the napalm already in use in Viet Nam, we doubt if many villagers would have trouble making up their minds.

With the entry of Chinese troops in the Southeast Asia conflict still a distinct possibility, we could do worse than consider the use of such a limited-warfare weapon. Such a decision would have to be made in full consideration of the political consequences and after a strong campaign to assure that such non-destructive weapons are indeed regarded as more humane than napalm and high explosives. Reaction to the Viet Nam disclosures indicate that the Defense and State Departments have not given adequate thought to the problem.

William J. Coughlin

THE BUSINESS PRINCIPLES OF AN AEROSPACE INDUSTRY

These statements of policy were presented at an Engineering Forum by Vice President of Engineering at McDonnell, Mr. Kendall Perkins. If you, as an engineer are encouraged to follow these principles in your work, you will gain. If you are successful in the pursuit of these goals, the Nation will gain.

"... Organizations, like people, have personality and character. The things which make an organization distinctive are the ways in which it differs from other organizations. These generally stem from subtle differences in the principles which guide it and the practices it has learned to follow. What then are the guiding principles at McDonnell?

"*We believe it is a good business principle, for example, to give high priority to anticipating and doing our best to meet the needs of the customer*—those needs which are really sound and will not change tomorrow. This often means passing up the easy-to-get contract, or the quick and easy solution to a problem, or even the approbation of a customer representative who may have become oversold on a particular project or a particular solution to a problem. Anticipating real and lasting customer needs often means creating something the customer hasn't yet asked for and doesn't yet want to buy—and then developing it and presenting it in such a way that the need becomes sufficiently apparent and pressing to open the door to a contract.

"We're not always right in what we believe the customer should have but we've found that timely and energetic effort to find what he needs, and to find an optimum solution, pays off handsomely in the long run. It was this principle which led us to start work on a manned orbiting spacecraft more than a year before the NASA asked for bids on Mercury. The same principle led us to undertake the design of an unusually versatile, high performance fighter for the Navy more than a year before our first Navy contract for Phantom II's. Thus it might be said that our largest current contracts have stemmed from the practice of anticipating customer needs. We still look forward to sizable production contracts for products conceived several years ago and actively developed since.

"*We believe it is a good business principle to give high priority to meeting the needs of the individuals who make up our organization.* This means many things in addition to a fair salary. It means treating people as they should want to be treated—with fairness and understanding. It means defining responsibilities and necessary constraints, but not blocking initiative. It means opportunities for personal development by training, and freedom to transfer to other kinds of work. It means opportunities to contribute to attainment of worthy objectives. It means opportunities to advance to positions of responsibility and recognition, depending primarily on such contributions. It means the fairest and most thoughtful attention to adjustments in position and salary.

"We're not always right in our treatment of people but it's not for lack of trying at all levels. Our record has been outstanding in that we have close to the highest morale and close to the lowest percentage of terminations in the aerospace industry.

"*We believe it is a good business principle to effectively foster cooperation between people.* It may sound corny to talk about team action as much as we do. But nowhere in industry is there so great a need for cooperation—internal and external—as in the aerospace industry. Few other industrial products are as complex or as dependent upon such advanced engineering as a manned spacecraft or high performance aircraft. Few require so many kinds of engineering talent interacting toward the solution of so many kinds of problems. Few products require reconciling so many requirements expressed by so many people in so many documents. In short, there is a demand for effective coordination in the thinking of great numbers of people unmatched in any other industry.

"There is no such thing as an expert in all phases of an airplane, a missile, or a spacecraft. Successful systems of this complexity are developed only by employing the combined efforts of a team of people engaged in a wide variety of engineering and other activities. Technical areas are as far apart as chemistry and UHF radiation, hypersonic aerodynamics and gyroscope design, exotic high temperature materials and computer technology. No single brain can firmly grasp all these areas. Hence there is no substitute for an effective team—one whose members have learned to work together in harmony and mutual respect. The man who would lead such teams must be capable of grasping what is told by others and appreciating the implication, but he must be modest enough to depend on the abilities and judgment of others and delegate responsibility whenever he safely can. Advanced systems development cannot be successfully run in a high-handed manner.

"I feel we have been successful at McDonnell in creating a harmonious atmosphere and minimizing non-constructive controversy. I believe we have built a team where there is a real sense of pride in group accomplishment and, at the same time, recognition of individual accomplishment. There is acceptance of necessary constraints without undue loss of individual spontaneity. We in management do our level best to provide a climate where these things can happen.

"The process of fully considering inputs from, and working in close harmony with so many other people calls for a type of organization and a set of skills and habits not ordinarily taught in school. It calls for keeping our viewpoints as broad as we can. It calls for changing our minds when the logic of the situation demands. It calls for keeping the best interest of the customer and the company ahead of our own immediate desire. It calls for recognizing that the other fellow's opinion can validly differ from our own without signifying either poor judgment or questionable motives on his part. It calls for keeping our heads when those about us are losing theirs and blaming it on us. It calls for these and many other practices in good human relations.

"*We believe it is a good principle to make important decisions with the most meticulous care.* In comparing our company with others it strikes me that we are more careful than most about reaching our decisions. We have learned the importance of examining all alternatives, digging up all the pertinent facts, fully analyzing results, and being objective and thorough in our judgments. This has tended to become a habit, exasperating at times, but well worth it on balance. It began when the company was formed and, in my opinion, has had more to do with our success than any other single practice."

Engineers, Scientists, Physicists and Mathematicians with energy, enthusiasm, and great creativity are needed for projects in the national interest underway at McDonnell. If you would like to work where the business principles outlined above are corporate policy and where the pursuit of excellence is a permanent corporate goal, we urge you to complete and mail the brief resume form below.

MCDONNELL An Equal Opportunity Employer.

Mail This Form To: W. R. Wardle, McDonnell Employment, Dept. PP-419, Box 516, St. Louis, Mo. 63166

Name__________ Home Address__________

City & State__________ Phone__________ Age __________

Education: BS______ MS______ PhD ______ Major Field:__________

Date Date Date

Primary Experience Area:__________ Present Position:__________

__________ Number of Years__________ __________ I would like to receive application form ☐

FIRST FREE MAN IN SPACE

Circle No. 2 on Subscriber Service Card

From an original painting for Chandler Evans by Keith Ferri

CECO Main Fuel Pump selected for LTV A-7A

The A-7A, a light attack aircraft being developed for the Navy by Ling-Temco-Vought, is powered by a Pratt & Whitney Aircraft TF-30 jet engine—equipped with a main fuel pump engineered and precision-produced by Chandler Evans.

This CECO product on the A-7A joins a distinguished line of pumps, main fuel controls, afterburner controls and other aerospace components in an array of important military aircraft as well as many of the latest and finest missiles and commercial aircraft.

Chandler Evans is pleased to be "known by the company its products keep" and by the records those products establish.

Colt Industries **Chandler Evans Control Systems Division**

WEST HARTFORD, CONNECTICUT 06101

GAS TURBINE FUEL CONTROLS/PUMPS • MISSILE CONTROL SYSTEMS/SERVOS • AIRCRAFT/ENGINE ACCESSORIES

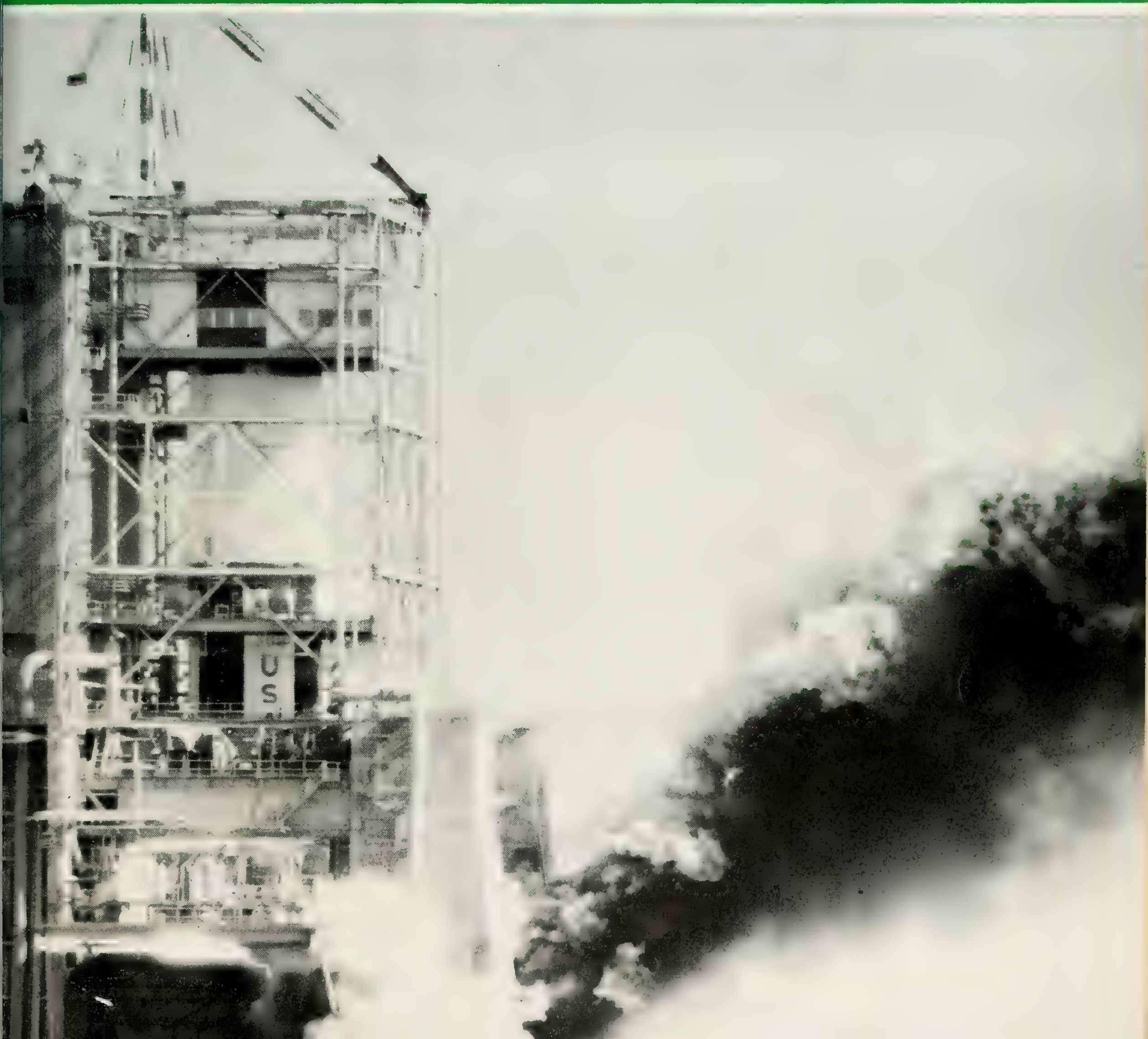
Circle No. 3 on Subscriber Service Card

APRIL 26, 1965

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

HOUSTON PUBLIC LIBRARY Houston, Texas



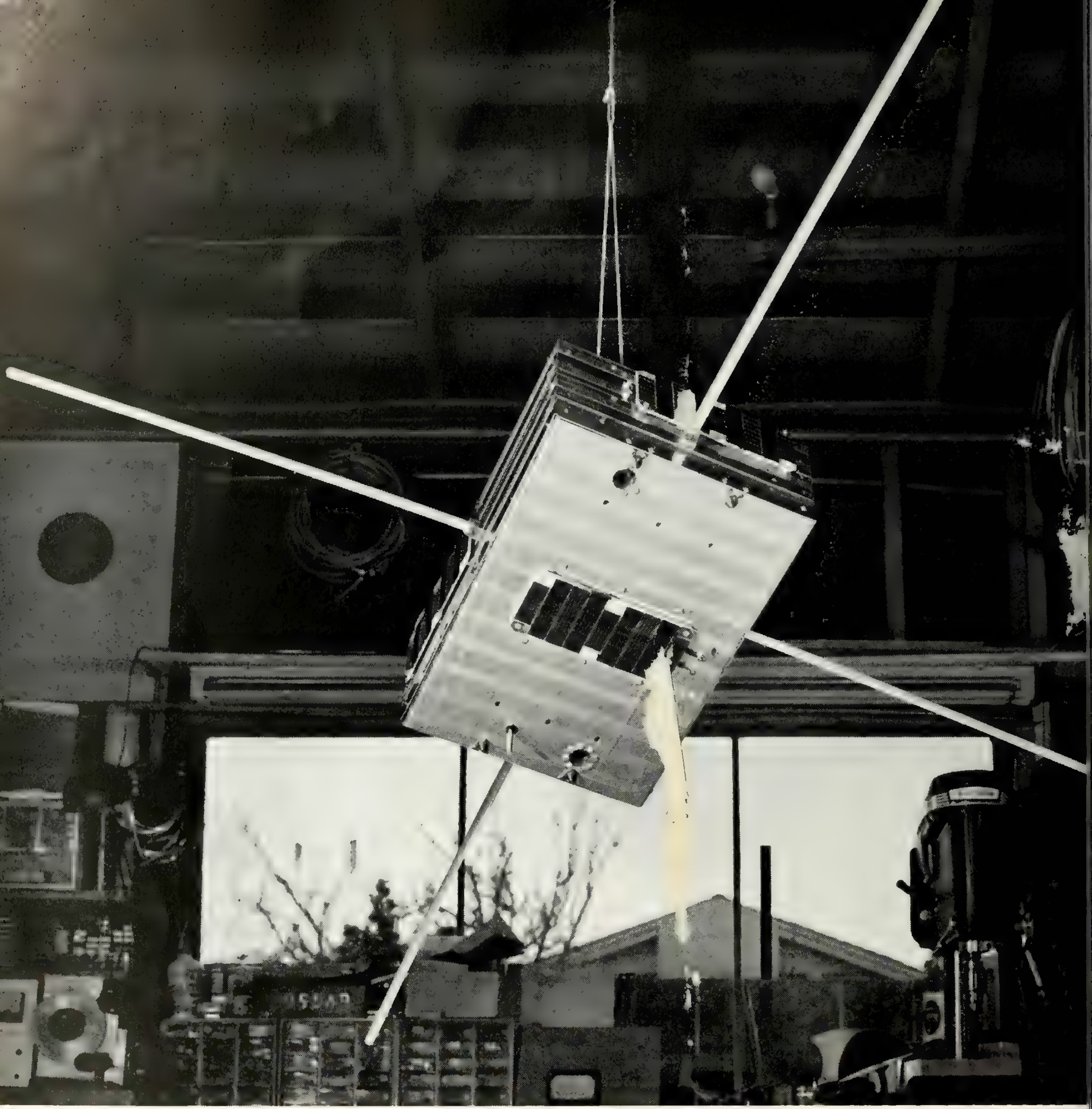
S-IC Stage of Saturn V Tested at Huntsville

NASA's Isotope Needs To Rise Sharply

MOL Program May Go Beyond Six Shot

Apollo Spacesuit Design Overhauled . .

CATION



How to build a satellite in your spare time.

The photo above, taken in a Los Altos, California, garage, shows the Oscar III communication satellite during the final stages of its construction. Built by a small group of ham radio operators, Oscar III was placed in orbit last month —hitching a ride aboard an Air Force rocket. This small, "repeater" satellite has already made it possible for hams around the world to communicate with each other on radio equipment normally restricted to short-range, line-of-sight broadcasts.

Although it is the smallest, most complex satellite of its type, Oscar III was a spare-time project in every sense, and many of its components are strictly products of its builders' ingenuity. For example, the four antennae you see are made from the steel of an ordinary pocket tape measure. But when it came to the critical electronic components, no substitutions could be made. Only th
best transistors available today coul
meet all the requirements...that's wh
the builders of Oscar III called f
Silicon Planar devices from Fairchil

FAIRCHIL
SEMICONDUCTO

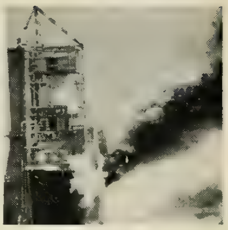
FAIRCHILD SEMICONDUCTOR/A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION/313 FAIRCHILD DR., MOUNTAIN VIEW, CALIF./962-5011/TWX: 910-379-6435

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 17 April 26, 1965

THE COVER



First static firing of all five F-1 engines in the Saturn V booster (S-IC stage) was conducted April 16 at Marshall Space Flight Center. The Rocketdyne engines were fired for 6½ seconds and produced a total thrust of 7.5 million lbs. More than 500 data measurements were made.

APRIL 26 HEADLINES

Eurospace Delegates Begin Wide-Ranging Tour 9
NASA Predicts Sharp Rise in Nuclear Power Use . . . 12
MOL May Expand Beyond Gemini/Canister Concept . . . 13
Martin Receives $16-Million Titan III-X Contract . . . 13
Cislunar MDS Decision Expected Within Two Months . 14
International Latex Still Seeks Spacesuit Work 14
Second Project Fire Launch Set for Next Month 15
Lunar Surface Bearing Strength Dispute Continues . . 16
Navy Facility Will Simulate Nuclear Explosions 17

ADVANCED MATERIALS®

Tape-Wrapping Technology Refinement Detailed . . . 22

LIFE SUPPORT

Apollo Spacesuit Undergoes Thorough Redesign . . . 26

ADVANCED ELECTRONICS

Cost Reductions To Greatly Expand Computer Use . 32
Sperry Delay Line Is Promising Development 34
Battery Materials Can Withstand Sterilization Heat . . . 36

DEPARTMENTS

Letters 4
The Countdown 7
The Missile/Space Week® 9
Technical Countdown . . 21
The Industry Week 39
Contracts/Procurements 40
Products & Processes . 42
Names in the News 44
When & Where 45
Editorial 46

48,175 copies this issue

Editor
William J. Coughlin

Managing Editor
Reed Bundy

Senior Editors
Charles D. LaFond . . . . Electronics
William S. Beller . . . . Engineering

Associate Editors
Lawrence J. Curran . . . . . . Assistant Managing Editor
Heather M. David . . . . Space Medicine
Michael Getler . . . . Electronics
John F. Judge . . . . Propulsion/Materials
Robert L. Parker . . . . Copy Editor
Rex [illegible] . . . . Electronics
[illegible] Taylor . . . . NASA
Donald L. Zylstra . . . . Military

Contributing Editors
David A. Anderton, Warren Burkett,
Robert Lindsey, Robert Twiss

drich Schonbach . . . . Art Director
ald Strickland . . . . Assistant Art Director
anne Montgomery . . . . Editorial Assistant
lv Fosnight . . . . Editorial Assistant

BUREAUS
LOS ANGELES . . . . . 9301 Wilshire Blvd., Beverly Hills
Willard E. Wilks . . . . Bureau Chief
NEW YORK . . . . 20 East 46th Street
Michael Getler
CAPE KENNEDY . . . . 507 Orange Ave.
Merritt Is., Fla.
MIDWEST . . . . 423 N. Quentin
John L. Zimmerman . . . . Wichita, Kan.
PARIS . . . . 11 Rue Condorcet
Jean-Marie Riche

EDITORIAL ADVISORY BOARD
Dr. Peter Castruccio Alexander Satin
Conrad H. Hoeppner Vice Adm. H. Sanders (ret.)
Richard F. Gompertz

•

James W. Claar
Publisher

A. C. Boughton . . . . National Sales Manager
Paul B. Kinney . . . . Eastern Advertising Manager
Edwin J. Denker, Jr. . . . . . Western Advertising Manager
Kenneth C. Blanchard. Marketing & Research Director
John N. Carlin . . . . Director of Circulation
Paddy Nelson . . . . Circulation Promotion
R. Virgil Parker . . . . Director of Production
Barbara Wiener . . . . Advertising Services Manager

Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
Copyright 1965, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

President . . . . Wayne W. Parrish
Senior Vice President . . . . Louis C. James
Vice President . . . . Fred S. Hunter

ircle No. 13 on Subscriber Service Card

CHR

Viton*, solid sheet and sponge that in the face of heat and fuel just takes it, and takes it, and takes it...

When you are at the end of your material imagination, looking for that something that will maintain its properties in the face of an impossible environment, take a good look at the specifications of CHR Viton sheet and sponge. To make your answer even happier, CHR distributors sell it right off the shelf. Viton sponge comes in 18″ x 18″ sheet size in ⅛″, ¼″, ½″ thicknesses. Solid sheet comes in 12″ x 12″, and 24″ x 24″ size, and in 1/32″, 1/16″, 3/32″, and ⅛″ thicknesses. This isn't the size you want? Give us a ring or drop us a line and we will tell you what we can do. For your local source and complete catalog data write the Connecticut Hard Rubber Co., New Haven, Conn. 06509.

*TM OF DUPONT

Circle No. 1 on Subscriber Service Card

letters

Eyeless on Mars?

To the Editor:

I have been reading your articles about *Mariner IV's* progress with great interest.

In the many reports that I have read, none has mentioned the fact that the region of Mars to be photographed, mainly the Mare Sirenum area, is famous for its dust storms. This area, and Phoenicis Lacus, are where the "W" clouds form and where a 350-mi.-long cloud has been observed. These clouds have lasted as long as 3 weeks or more. A dust storm, of course, would ruin the photographs on an otherwise perfect mission.

I don't believe that I am a pessimist, but I do have more faith in *Mariner* than I have in Mars.

Steve Reed
Port Hueneme, Calif.

Inventor Seeks Application

To the Editor:

I am writing in response to the question you posed in your editorial in the March 22 issue, "What is he working on that will change the world so vastly 39 years from now?"

I have a friend who has developed and patented a liquid compound with unique magnetic properties. This is a true liquid—not just magnetic particles in solution.

Since a fluid with magnetic properties could be of tremendous significance in space technology, we are attempting to find an application.

What assistance can your readers render in obtaining leads for the application of this magnetic fluid?

Any assistance you may give will be deeply appreciated.

Kenneth M. Timmerman
736 Pike St.
Cheyenne, Wyo.

Inside Sandwich Job

To the Editor:

Your April 5 editorial ("Fun and Games") was somewhat a surprise, for you have been, in my opinion, fair and just towards our Space Exploration. Your magazine has always been most interesting to read, but the editorial you have written, joining Mr. W. Hines of the Washington *Evening Star*, who has criticized our two Astronauts, has left me aghast.

You begin by admitting that Mr. Hines is "one of the most qualified and professional writers in the Missile/Space field." Mr. Hines could not have written as he did about J. W. Young and V. I. Grissom if he were the most qualified to write.

Because he, Mr. Hines, has expounded on the attitudes they (Young and Grissom) had during a press briefing on Thursday evening, he is trying to make the American public believe that this is also the attitude in the capsule during orbital flight. Let's not fool ourselves about what happens in flight. Our Manned Space Flight Center team should be the qualified authority on space flight behavior—not a pseudo authority like Mr. Hines.

As for the sandwich aboard, which is supposed to be the main issue, and the "flippant" attitude during the press conference—the second issue as to behavior. Do you honestly think a sandwich could be secretly stolen aboard the capsule? It is very improbable that it be carried to and into the capsule unnoticed by all personnel within the white room. To accomplish the act, Young must have had an assistant, partner or colleague that day; or Grissom ate an old stale sandwich put on board during simulated flight tests days before their flight.

I cannot conceive that such a highly trained person would jeopardize one small bit of information from space flight by consuming one sandwich. I am quite sure that before this act took place, an evaluation was made to decide if it were right, wrong, or of marginal consequence.

May I say that today's American should have a symbol of heroism or something other than the overwhelming propaganda in the news about Communism, military aggression, discrimination and all other items concerning violence. In the field of science, there is a positive need for more young, devoted engineers and scientists. What rewards should the young scientist look for? Self-esteem, praise and heroic imagery or degrading criticism from individuals of the press who can and have controlled the future accomplishments of scientists by their lack of knowledge.

From this date on, I am relying on the Space Flight Reports published by our Library of Congress, as I did initially on *Mercury* Flight "Freedom 7," with John Glenn aboard. These reports do not have personal feeling interfering with the true interpretation of excellent or poor results from space flight.

E. A. Gardner
Michoud Operations
New Orleans, La.

Right Caption, Wrong Photo

To the Editor:

Looking closely at the caption of the top picture on page 14 of M/R, March 29, I could not believe my eyes. Did the *GT-3* astronauts have to stay in the "bobbing" capsule until the hatch was opened? if so, how did the technician (minus frogman paraphernalia) open the hatch? The picture closely resembles a pre-launch photo of a technician checking the hatch prior to flight. Please verify.

R. G. Pokraka
Sr. Applications Enginee
McCormick Selph
Hollister, Calif.

It is indeed a pre-launch photo, and th caption involved belongs to another photograph (post-impact) that was tentativel scheduled to be used with the GT-3 articl but was not.—Ed.

Careers on the move in **satellite boosters**

You're looking at the start of another successful satellite boost by the NASA/Douglas *Delta,* the most reliable launcher in the world. It has a record of 22 successful orbitings in succession.

But more is now required of it. Tomorrow's assignments demand more lift, more capacity, even more precise guidance. And each launching creates new problem areas requiring solution.

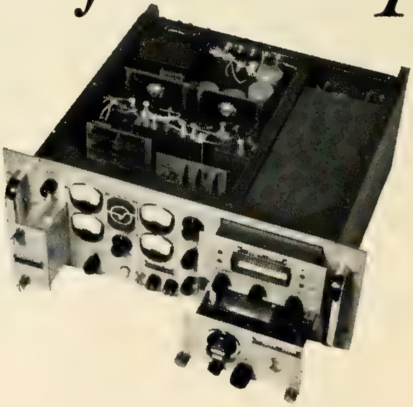
Douglas is seeking qualified aerospace engineers for long range programs on this and other projects. Immediate openings exist in the following areas: structures, guidance and control, propulsion and reliability. However, we welcome inquiries from those with experience in other disciplines.

Please send your resume to Mr. I. P. Snodgrass,

DOUGLAS

MISSILE AND SPACE SYSTEMS DIVISION
2700 Ocean Park Blvd., Santa Monica, Calif.
An equal opportunity employer

This is Vitro Electronics' Telemetry Receiver · It is Type 1037A · It is not new It is thoroughly field-proven · It is in its fifth production run · It is the standard for comparison



The 1037A is still the only advanced type telemetry receiver that is in full production with a long and successful history of field-proven performance and reliability. The 1037A offers a wide choice of off-the-shelf plug-in RF tuners covering a range of 55-2300 mc and the most versatile group of IF demodulators available which include true phase with long or short loop, linear phase for special PCM applications, phase tracking, high capture ratio, phase lock, FM and AM for all known telemetry formats. Integral plug-in predetection converters and spectrum display units optional. Improved adjacent channel rejection and optimum combination of RF nuvistors and solid state design avoid the dynamic range problems inherent in solid state RF tuner designs.

Vitro Electronics is also the only manufacturer with a complete line of off-the-shelf solid state pre- and post detection combiners, dual diversity receivers, up and down converters, multicouplers, preamplifiers, etc.

For a complete new catalog or additional details please write to
Vitro Electronics, 919 Jesup-Blair Drive, Silver Spring, Maryland.
VITRO CORPORATION OF AMERICA · 90 PARK AVENUE · NEW YORK, N.Y. 10016

Vitro

Circle No. 2 on Subscriber Service Card

The Countdown

WASHINGTON

NASA Ponders Minuteman Boosters

DOD has asked the space agency to consider using *Minuteman I* missiles scheduled to be removed from their silos as launch vehicles. After about two months of consideration at NASA headquarters, the study is being transferred to Langley Research Center, indicating NASA officials believe the scheme may be feasible. The Center is expected to finish its investigation in three to four weeks. The *Minutemen* might be used as solid strap-ons, given a fourth stage and employed to orbit payloads, or cannibalized—with some of the upper stages being used to beef up other NASA launch vehicles.

Proposed Missile Would Double SRAM Range

Air Force is negotiating a $10-million contract for feasibility flight testing aimed at an air-breathing *Low-Altitude Supersonic Research Missile (LASRM)* that might have twice the range of the *Short-Range Attack Missile (SRAM)* now in early development. Marquardt is reported to be one of the firms involved in the negotiations with Wright-Patterson AFB. The missile would use a liquid hydrocarbon fuel with boron additive. Edwards AFB reportedly sent out RFP's recently for development of an engine that would be similar but would have an air-augmented solid fuel.

S-IC Testing Slips Ahead of Schedule

Static test-firing of the *Saturn V's* S-IC first stage is now two months ahead of schedule, following the first firing of the combination of five Rocketdyne F-1 engines at Marshall Space Flight Center April 16 (see cover). That 6½-sec. test was originally slated for June. The next firing—for 15 seconds—now is due on May 1. First full-duration 2½-min. test is set for mid-July.

EVA Suit Now Official for GT-4

Manned Spacecraft Center now has announced officially that the *Gemini/Titan II-4* astronauts will wear the recently qualified Extravehicular Activity (EVA) spacesuit during their flight (M/R, April 19, p. 24). NASA spokesman still say officially that extravehicular activities such as opening the hatch and having one astronaut stand up will not take place until the fifth flight, but there now seems to be a good chance that this will be done during *GT-4*.

MOL To Borrow from Previous Programs

DOD has chosen a number of subsystems that will be adapted for the *Manned Orbiting Laboratory* from earlier space programs to hold down costs. They include astronaut spacesuit, electrical-power fuel cell supply, environmental control system, attitude-control reaction-jet system, man-rated battery systems, digital flight-control computers, attitude sensors, and life-support provisions.

DOD Maps Ground Support for MOL

Dept. of Defense estimates that a ground support system adequate to *MOL's* requirements could be made up of elements of the National Range Division, the Air Force Satellite Control Facility, and occasional use of one or two NASA stations. Incremental cost over the duration of the program would be in the neighborhood of $23 million.

ASMS Snarled by DOD Objections

Disagreement over concept is forcing slippage in Navy's *Advanced Surface Missile System (ASMS)* program. The service recently submitted a proposal only to have it disapproved by Dr. Eugene Fubini, assistant secretary of defense and deputy director of DDR&E. It is now restudying the proposal to try to satisfy these complaints. It is now doubtful that Navy can meet its mid-1965 target date for picking a program definition phase contractor, although it may yet come before the end of the year. For the time being, the pre-PDP contractors—Boeing, GE, Raytheon, Sperry Rand, RCA, Hughes and Westinghouse—have been awarded $90,000 contract extensions to keep component work going.

New Directorate in Works for Apollo Extension

While headquarters approval has not yet been received, NASA's Office of Manned Space Flight is expected to add a fifth directorate to head the *Apollo* Extension Systems program. AF Gen. David M. Jones, presently deputy associate administrator for programs, is expected to be named chief of the office, at least temporarily. The only sub-office which has thus far received OMSF approval is the *Saturn IB/Centaur* division. Another division to run the *Apollo X* spacecraft program is also expected to be set up.

Non-Profit Basic Research Gets $24.8 Million

Dept. of Defense has reported that U.S. and foreign non-profit institutions for basic scientific research were awarded DOD grants totaling $24,776,021 in calendar 1964. There were 707 such grants from the Army, Navy and Air Force, of which 568 went to domestic institutions and 139 were made abroad. Money value of the overseas awards was $2,452,372. Value of equipment transferred to organizations working under the grants is included in the overall total, such costs being estimated at the equipment's original value when acquired by the government.

Still More Hearings on Research Impact

The umptieth round of Congressional hearings on "The Impact of Federal Research and Development" is slated for late May or early June. This time the sounding board will be the Employment and Manpower subcommittee of the Senate Labor and Public Welfare Committee. Objective is to add data gathered by the House Science and Astronautics Committee and the House Select Committee on Government Research, and to define what new policies might be in order.

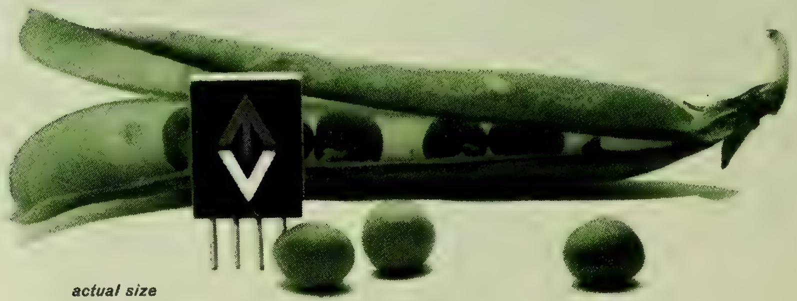
INDUSTRY

New Parachute Recovery Mode for S-IB

A parachute recovery system for the *Saturn* S-IB is being proposed to NASA by Northrop Corp.'s Ventura Division. A cluster of 205-ft.-dia. Ringsail chutes would be employed for ocean recovery, after which the booster would be towed back to the launch area. The space agency reportedly has been considering utilizing surplus *Redstone* missiles at Wallops Island to study the recovery problem.

Voyager Studies To Be Announced Shortly

Recommendations in the contractor competition for first-phase studies of the *Voyager* spacecraft program were presented by NASA's Source Evaluation Board last week. Announcement of two or three contracts is expected in the near future.



A TRULY MICROMINIATURIZED SOLID STATE VCO

Voltage Controlled Subcarrier Oscillator Vector Model MMO-11

Built to the highest reliability specifications using the most advanced thin film and integrated circuit techniques. ■ MTBF figure is 400,000 hours.

Designed to meet the severest environmental specifications ■ Flight proven on one major program to 10,000 g shock for three milliseconds.

Also available: Mixing amplifiers built with same microcircuit techniques, and mounting assemblies for complete system integration.

Weight: 0.13 ounces ■ Size: 1.00" x .722" x .150"
Power Requirements: Unregulated 28V DC

IMMEDIATE DELIVERY FROM STOCK

Vector DEPARTMENT OF NORDEN DIVISION OF UNITED AIRCRAFT CORPORATION
SOUTHAMPTON, PENNSYLVANIA Telephone 215 EL 7-7600

The Missile/Space Week

Eurospace Tour Begins

More than 100 delegates from Eurospace begin a two-week conference and tour of U.S. aerospace installations April 26 in Philadelphia. They will be joined by a similar number of representatives from U.S. industry. The wide-ranging tour will end May 7 on the West Coast.

Purpose of the U.S./European Space Conference is to bring together top industrial leaders from European and American aerospace companies to review the problems the evolution of space technology poses for the industry.

The principal technical sessions will take place in Philadelphia April 26-28. During the tour, the Eurospace delegates and their U.S. colleagues will also visit the NASA Kennedy Space Center, Cape Kennedy; the space agency's Goddard Space Flight Center, Greenbelt, Md.; plus facilities of U.S. firms corresponding to Eurospace member companies.

U.S. firms included on the agenda are Westinghouse Electric Corp., Baltimore; Martin Co., Denver; The Boeing Co., Seattle; Republic Aviation Corp., Farmingdale, N.Y.; Lockheed Aircraft Corp., Sunnyvale, Calif.; Aerojet-General Corp., Palo Alto, Calif.; Douglas Aircraft Co., Sacramento and Los Angeles; Hughes Aircraft Co., Los Angeles; General Dynamics Corp., San Diego; General Electric Co.'s Valley Forge, Pa., Space Technology Center; and TRW Space Technology Laboratories, Los Angeles.

Procurement Hearings Set

Hearings on the "Economic Impact of Federal Procurement" will be held by the Congressional Joint Economic Committee's subcommittee on Federal Procurement and Regulation April 27, 28, and 29.

Main topics in the hearings, which are a follow-up on the program the subcommittee (formerly named the subcommittee on defense procurement) has carried out over the past five years, will be DOD's cost reduction program, standardization of supply items, elimination of items from the supply system, the Federal supply system, procurement and use of automatic data processing equipment, the Budget Bureau's role in these matters and other subjects.

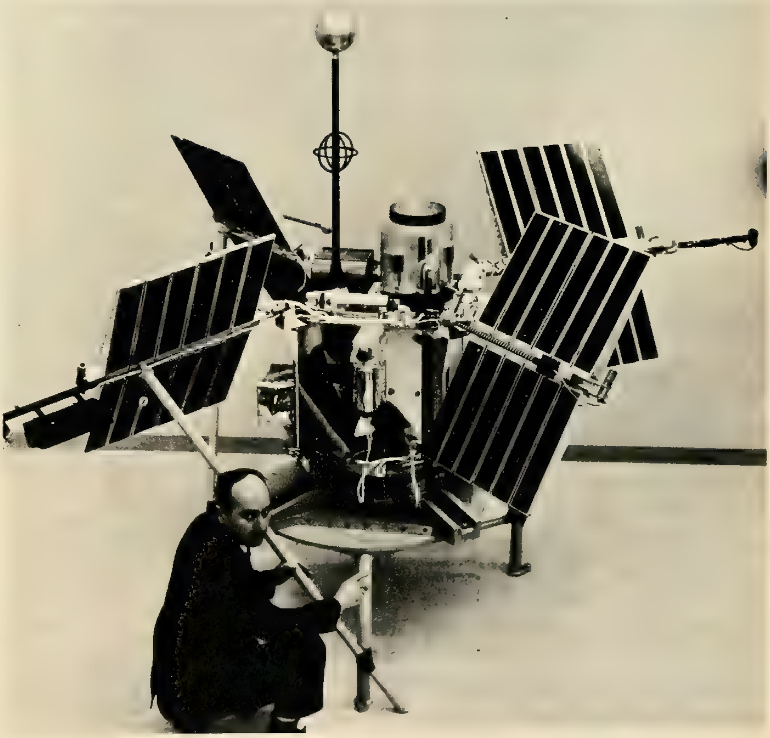
Secretary of Defense Robert S. McNamara will lead off the witnesses on Tuesday, accompanied by Paul R. Ignatius, assistant secretary. Director of the Supply Agency Joseph M. Lyle will follow in the afternoon. Other witnesses during the next two days will be Joseph Campbell, Comptroller General of the U.S., Lawson B. Knott, Acting Administrator, General Services Administration, and Kermit Gordon, Director of the Bureau of the Budget.

Mariner Hit by Cosmic Dust

Micrometeoroid hits on the *Mariner IV* spacecraft are increasing as the spacecraft nears Mars.

At a meeting of the American Geophysical Union in Washington, scientists associated with the project reported that *Mariner IV* has absorbed 95 impacts in interplanetary space, after traveling approximately 3,350 hours. The rate in recent weeks has been about 10 times that in the first weeks after launching Nov. 28.

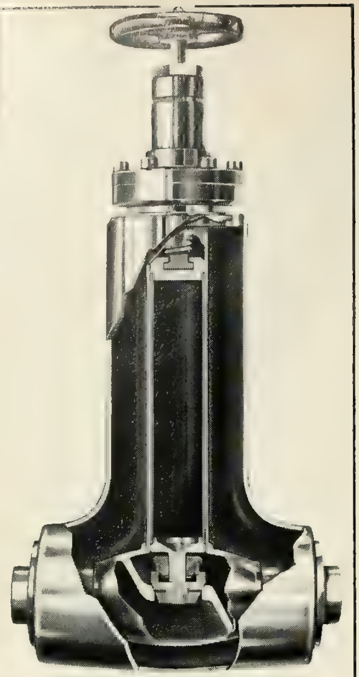
According to W. M. Alexander, a Goddard Space Flight Center scientist, there is no indication whether the increase was due to its proximity to the asteroid belt—which is still far on the other side of the planet Mars. He also pointed out that the plate has been exposed to high-inclination particles as well as the low-inclination particles such as those in the asteroids. Consequently, he said he could



Northrop Completes Satellite for OAR

THE AIR FORCE'S OV2-1 space-environment-sensing satellite, built by Northrop Space Laboratories for the Office of Aerospace Research, has been assembled and is undergoing a programmed series of systems tests, according to William C. Armstrong (foreground), Northrop program manager. Next step will be delivery of the Orbiting Vehicle 2—Article 1 to Cape Kennedy, where it will be carried aboard a Titan III-A late this spring as a bonus payload during a development launch of the booster. Due for a one-year orbital life, OV2-1 will carry sensing instrumentation for 14 space environments. It will be placed in an elliptical orbit ranging from 100 to 2,400 n. mi. Two follow-on satellites are planned, OV2-2 and OV2-3.

← Circle No. 15 on Subscriber Service Card



It solved our cryogenic fluid handling problem... We think it will solve yours, too.

Question: What do you do when you can't find a commercially available valve to meet your exacting requirements for cryogenic transfer line systems? Answer: Design your own. This is just what our engineers did, the result: a new series of jacketed and unjacketed valves for low loss handling of cryogenic fluids in five sizes from ½" to 2". Here are just a few of their features that we think will help solve your problems: high flow . . . low cool-down losses . . . low heat leak . . . bubble-tight shutoff . . . zero stem leakage . . . ease of operation and, most important, reliability. What's more the Series V-1060 Valves are available in three modes of operation—Manual, Cylinder and Positioner. Why not get the facts, write for our Bulletin 206.

cvi

CryoVac INCORPORATED

COLUMBUS 12, OHIO

not see how the asteroid group could cause all the impacts.

Richard Sloan, *Mariner* project scientist at Jet Propulsion Laboratory, also revealed that the laboratory will attempt to pick up the spacecraft after it goes around Mars and the Sun and comes back into opposition with the Earth in 1967.

LEM Ascent Engine Fired

NASA put the Lunar Excursion Module ascent engine to its first test April 15 at White Sands Missile Range, N.M. The initial test consisted of a 5-second firing under ground level conditions and was conducted by Grumman Aircraft Engineering Corp., LEM prime contractor.

Space agency officials said initial indications were that the test had been good. They termed it, "another milestone in the U.S. manned lunar exploration program."

The 3,500-lb.-thrust hypergolic engine is built by Bell Aerosystems Co. of Buffalo, N.Y., and uses the same fuel and oxidizer as the spacecraft's reaction control system—a 50/50 mixture of UDMH and hydrazine, for fuel, and nitrogen tetroxide for the oxidizer.

New Facility at Edwards

A $2.3-million test facility expected to improve space storability of liquid and solid rocket propulsion systems will be completed this month at the Air Force Rocket Propulsion Laboratory at Edwards Air Force Base, Calif.

The new facility, consisting of a 30-ft.-dia. stainless steel spherical chamber in a 7,500-sq.-ft. assembly building and an instrumentation complex, will be capable of subjecting test items ranging from complete engines to advanced propellants to many of the environmental aspects of long-term space storage.

The chamber is fitted with a removable 19-ft.-dia. lid and an 8-ft.-dia. personnel entry hatch. It will accept test articles up to 16 ft. wide, 20 ft. long and weighing over 100,000 lbs. The assembly building includes a 60-ton capacity overhead crane.

Simulated altitudes in excess of 600,000 ft. will be obtained, with temperatures ranging from —300°F to 400°F. Solar heating will be simulated with an infrared source.

Instrumentation systems consist of more than 470 instrumentation channels and 50 control channels. Data will be recorded with a 200-channel digital acquisition system, augmented by FM tape data collection equipment, ship charts, oscillographs and discrete event channels. A separate reinforced concrete building 900 ft. away will house control and instrumentation equipment.

AEC Pact Awarded

Negotiation of a contract under which a Douglas Aircraft Co.-United Nuclear Corp. joint venture will operate the reactor and fuel fabrication facility of the Atomic Energy Commission's Hanford (Wash.) Plant (M/R, Nov. 16, 1964, p. 10) is due to begin this week. Value of the award is expected to be $30 million a year.

Douglas and United Nuclear were selected for the job on the basis of proposals presented by Douglas and by United Nuclear and Monsanto Research Corp. jointly. Monsanto released United Nuclear from their joint proposal and withdrew from the competition.

Among the most attractive aspects of the Douglas-United Nuclear proposal were plans submitted by the companies, both individually and jointly, to bring new business to the Hanford-Richland, Wash., area. Douglas is due to begin construction of laboratories near Richland to concentrate on research and development in application of nuclear energy to space vehicle and energy conversion systems.

United Nuclear will construct a zirconium tubing plant in the Hanford area. The joint firm will construct a facility for the fabrication of plutonium at an initial capital cost of $2.6 million.

General Electric Co., which has been the principal contractor at Hanford since 1946, will continue to operate part of the installation.

Shots of the Week

The Army's *Lance* tactical missile underwent its second successful test firing (M/R, March 22, p. 10) April 15 under direction of an LTV Aerospace Div. crew. All primary test objectives were said to have been met in the firing at White Sands Missile Range, N.M., from a non-tactical launcher. Under operational conditions, the *Lance* will be launched from a modified M113 tracked armored vehicle.

- A Strategic Air Command crew launched two *Minuteman* ICBM's within minutes of each other from Vandenberg AFB, Calif., April 13. The technique is one that would be used to counter a surprise attack.

- Nasa launched an *Argo D-8* sounding rocket from Wallops Island, Va., April 14, but was unsuccessful in an attempt to gather correlated radiation belt data while the *Orbiting Geo-*

Circle No. 11 on Subscriber Service Card

physical Observatory passed overhead. The rocket performed properly, but the nose cone, which covered the instrumented payload developed by the University of Minnesota, failed to eject.

Confinement Test Completed

Eight Navy and Marine aviators have completed a 34-day confinement test and simulated space journey in two separate chambers, the largest of which is approximately the theorized size of the *Manned Orbiting Laboratory.*

Six of the eight officers were confined in a steel drum measuring 10 ft. in diameter and 20 ft. in width at the Naval Air Engineering Center at Philadelphia.

Physicians associated with the project, which is sponsored by NASA, said that there were no serious problems and that the simulation indicated there would be no serious psychological difficulties in spacetrips of this duration. Two chambers were used, the smaller housing the remaining two men.

No MRBM's in Cuba

Top intelligence officials have agreed that presently there are no medium range ballistic missiles in Cuba, the House Committee on Foreign Affairs revealed.

The committee said in a report to Congress that testimony taken by the subcommittee on Inter-American Affairs indicates that the intelligence community is satisfied that "the varying reports of missiles in caves in Cuba or movement in below-deck shipment on vessels are unfounded."

These reports, the committee said, can be traced to the movement of antiaircraft missiles or to the movement of shorter range tactical-type missiles that are known to be in Cuba in some numbers.

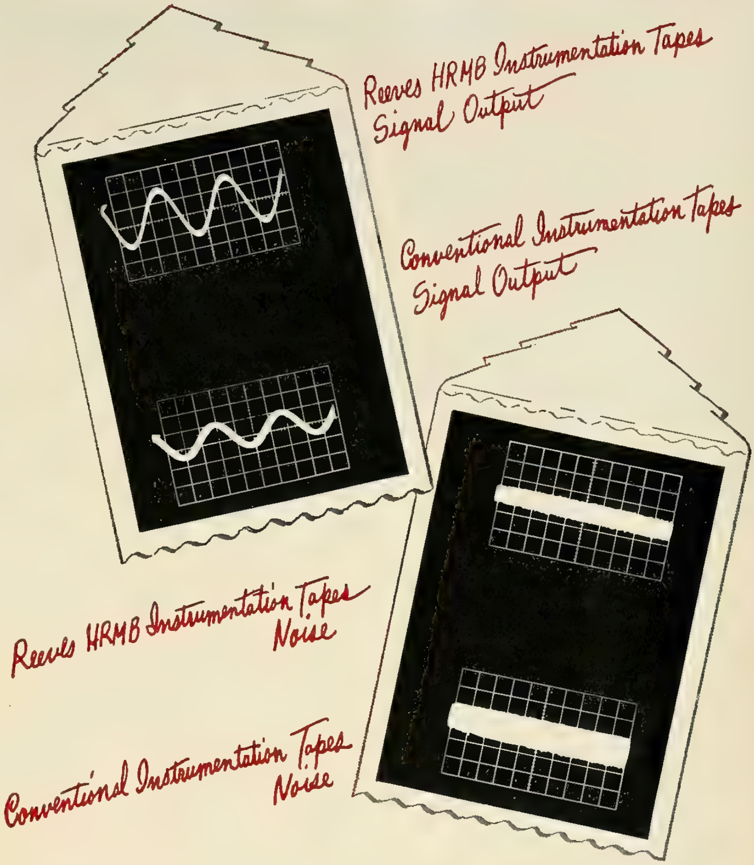
Intelligence officers are reported as feeling that the frequency of high-altitude U-2 flights presently being maintained is adequate to safeguard U.S. national security interests.

Satellite Explosion Reported

A Danish satellite tracking station official has reported what he believes to have been the explosion of an American satellite launched by the Air Force March 25 (M/R, April 5, p. 10).

Several Danes reported seeing about 10 brilliantly lighted objects crossing the sky on the night of April 5. They were at first assumed to have been meteorites.

SEE WHY THE NEW
REEVES INSTRUMENTATION TAPES ARE THE
ONLY TAPES YOU CAN AFFORD TO USE?


Reeves HRMB Instrumentation Tapes
Signal Output
Conventional Instrumentation Tapes
Signal Output
Reeves HRMB Instrumentation Tapes
Noise
Conventional Instrumentation Tapes
Noise

This dramatic advance in performance is the result of Type HRMB's special oxide and binder system combined with MICRO-PLATE* — Reeves Soundcraft's exclusive new process which produces the smoothest surface in a tape today.

In addition to its better signal output and noise characteristics, Type HRMB offers these improvements over conventional instrumentation tapes:

• Lower distortion • Freedom from shedding (oxide and binder are locked together) • Lower head temperatures and less abrasiveness — assuring longer head and tape life • Higher electrostatic conductivity for uniform static drain.

Available in "A" oxide for normal bandwidth applications—"B" oxide for extended bandwidth applications. Write for new Reeves Soundcraft Instrumentation Tape brochure.

Polaroid photos are actual tests of tapes run on Sangamo Model No. 4742 recorder reproduce system.

*Reeves Soundcraft T.M.

REEVES SOUNDCRAFT
DIVISION OF REEVES INDUSTRIES INC.
GREAT PASTURE ROAD, DANBURY, CONN.

New York • Chicago • Los Angeles • Export: C.B.S. International, 46 E. 52 St., N.Y.C. • Canadian Reps: Toronto

Circle No. 3 on Subscriber Service Card

NASA Sees Rising Need for Isotopes

Future requirements include supply of plutonium-238 up to 500 KWt by 1980; other sources listed; letter seen as evidence of confidence

by Hal Taylor

NASA HAS FINALLY firmed up its isotope requirements for nuclear power units and has informed the Atomic Energy Commission that it foresees a sharp increase in their use in the U.S. space program.

Administrator James E. Webb, in a letter to AEC chairman Dr. Glenn Seaborg, said that "NASA would support the AEC in producing plutonium-238 up to 500 KWt (kilowatt thermal) by 1980."

In addition, Webb said there might be a requirement for even more Pu-238 if certain future missions are improvised. He also indicated a future need for other isotopes such as polonium-210, curium-244 and promethium-147.

The magnitude of the planned increase in isotope use in space-power units is illustrated by the size of the projected use of Pu-238. The projected need for 500 KWt compares with NASA's current use of only two 25-w units which will power a *Nimbus* satellite that is slated for launch during 1966.

The letter was transmitted to Seaborg following a space agency review of its potential need for various isotopes to be used in space-power devices in the light of AEC-supplied production and cost dates.

- **"Maintain option. . ."**—"We expect that more than 500 KWt may be needed if certain manned missions are implemented and if they require Pu-238, but it is not now obvious that action to increase the quantities beyond 500 KWt should be taken at this time, particularly since many potential NASA missions are not yet defined or approved," Webb commented in discussing Pu-238.

He said that it appeared that a combination of AEC enlarged capacity plus increasing isotope quantities that could be obtained from civilian nuclear power industry can meet the agency's foreseeable future needs.

"Accordingly," he continued, "the AEC should maintain the option in its planning to increase radio isotopes production to the larger quantities. At the same time, it is clear that Pu-238 may not be exclusively needed for all of our proposed uses, since Po-210, Pm-147 and Cm-244 may be substituted in some cases."

In discussing some of the other isotopes, Webb said that polonium-210 appears to be most useful to NASA for missions of short duration or those which require a resupply capability. Since the leadtime for increasing its production is about the same, or less than, the time required for developing mission hardware, he said that efforts to increase production should not be initiated until applicable missions are defined and authorized.

The isotope also requires a careful production schedule because of its relatively short half-life.

- **Other possibilities**—Promethium-147 was also singled out as attractive for certain space missions. Production in line with classified AEC plans was recommended by the agency. It was also recommended that the AEC pursue methods of obtaining increased amounts of Pm-147 if the price tag can be held to the current level.

The agency's evaluation of curium-244 was also favorable because of its half-life, apparent performance and potential availability in large amounts on relatively short notice. The evaluation is uncertain, however, because NASA feels there is a lack of complete or precise knowledge of its properties.

Definitive requirements for it will be made after the AEC determines its properties.

Use of strontium-90 was ruled out by the space agency because of safety requirements and unresolved spacecraft integration problems.

The letter also recommended that the AEC continue its efforts to gather data on the isotopes discussed so that NASA can improve its evaluation of requirements.

It also suggested that the "AEC include in its research program the materials properties that are currently lacking or in doubt; the development and validation of improved fuel forms and encapsulation of the most promising isotopes; precise determination of the criticality of Pu-238 and Cm-244; validation of the safety of heat sources as large as 50 KWt which may be used; and any other problems that may be encountered during the utilization of isotopes for the production of space power.

"As part of this investigation, the accurate determination of Cm-244 properties should be accelerated. Finally, it is suggested that sufficient work should be accomplished to provide details of yields and costs of the isotopes of interest at several levels of production at minimum cost up to 250 KWt annually, if appropriate, for the decade 1970 to '80. Further, as future space missions become defined, we will keep the AEC informed as to power requirements for inclusion of isotopes SNAP devices in NASA space vehicles."

- **Faith in future**—The AEC has wanted NASA to make an estimate of its future needs, but the space agency until now has been reluctant, primarily because many of the programs which will use isotope units have not yet been officially approved.

The letter thus is important because it indicates that NASA now has sufficient faith in what its future missions will be to make a projection of its requirements.

Webb told Seaborg that calculations of these future needs are necessarily tentative, but that a better estimate will be available after the results of the *Gemini* two-man space flight program are known.

He also said that at about the same time NASA will be able to evaluate studies of the unmanned *Voyager* Mars exploration program.

He said, however, that the estimates of future requirements were based on studies of future missions—studies which indicated that there is a good probability that the isotopes mentioned in the letter will be required in quantities above those currently being produced. ■

No six-launch limit . . .

MOL Experiments May Require Apollos

Some hardware already being tested; many packages apparently will be aimed at Earth surveillance; all concerned eager for final source selection

by Donald L. Zylstra

MANY OF THE experiment packages being considered by the Air Force for the *Manned Orbiting Laboratory* program would require use of an *Apollo* capsule. They are beyond the capability of a configuration limited to the *Gemini* capsule, which will be used in early *MOL* experiments.

This was made clear last week as program officials continued negotiations with NASA for two *Gemini* capsules to be modified by McDonnell Aircraft for pre-*MOL* launches (M/R, April 19, p. 12).

Literally hundreds of experiments were initially considered for the *MOL* program, but the total now has been boiled down to 20-30.

Ground simulation and flight tests are already under way for some experimental hardware and other experiments may change considerably before the first launch of a fully configured *MOL*. The Dept. of Defense proposed 10 of the 17 experiments scheduled for the first three manned flights of *Gemini*. Much of the data sought may be supplied in NASA *Gemini* flights and these findings inevitably will lead to changes in similar experiments planned for *MOL*—where more sophisticated hardware and longer periods for observation will be afforded.

Long-standing DOD requirements for data leading to successful manned operation in space are being approached through experiments included in the NASA *Gemini* flight program, including: visual definition of objects in space, visual definition of terrestrial features, radiation measurements, radiometric measurements, radiometric observation of objects in space, testing of astronauts' visual acuity and visual definition of objects in proximity in space.

Among the experiments being tailored expressly for *MOL* use are three designated P-13, P-14 and P-15. P-13 has been identified as Navy's ocean surveillance experiment; P-14 is concerned with development of large erectable antennas and telescopes; and P-15 is an experiment involving the design and use of large optical devices. All three lend additional emphasis to the growing belief that a large number of *MOL* experiments will be directly concerned with development of Earth surveillance techniques.

- **Open-ended**—The total of six *MOL* launchings often mentioned is not and never has been an established figure. DOD personnel connected with *MOL* consider it definitely an open-ended effort. They emphasize that a fixed number of flights would be undesirable, as would a limitation on capsule hardware or an arbitrary elimination of any rendezvous requirements.

The *MOL* program as first announced nearly 16 months ago by Secretary McNamara is now being viewed increasingly as merely the first phase of a much more ambitious manned orbiting laboratory program.

Instructions to Boeing, Douglas, General Electric and Lockheed—the four firms now conducting Air Force *MOL* studies due by the end of this month—did not necessarily limit development proposals to use of the *Gemini* capsule but merely specified preparation of a study report using the *Gemini*/canister/*Titan III-C* configuration "for illustrative purposes only."

Even the $150-million FY 1966 budget request for *MOL* development is not predicated on plans to acquire a specific number or type of capsules such as *Gemini* or *Apollo*. Conceivably, either could still be used, despite announced plans to launch two unmanned *Gemini*-simulated canister "pre-*MOL*" configurations late in 1966 (M/R, April 19, p. 12).

Selection of a single prime contractor following current studies, or authorization of a runoff competition between two potential primes, wouldn't necessarily bring *MOL* closer to its ultimate design. The program definition phase (PDP) is expected to determine the eventual size and scope of the program. All concerned with *MOL* agree that an early final source selection would "benefit everybody"—the winning and losing contractors, DOD, NASA and the space program in general. First launches in 1968 are still the professed DOD goal. In fact, this date is the only firm one ever mentioned in the program.

- **Between the lines**—In many respects more can be learned about *MOL* through what is *not* being said than through any specific release of data, since most information remains highly classified. Most details have yet to be pinned down—including the exact number of *MOL* astronauts.

In his first announcement of the program, McNamara used the word "several." Subsequent assumptions that there will be only two have not been confirmed, and knowledgeable observers note that "several" *could* be construed to mean the three men who could be carried in the *Apollo*. ■

Martin Gets $16 Million for Titan III-X

A $16-MILLION Air Force contract has been awarded by the Air Force to Martin Company's Denver Div. toward development, production and launch of the *Titan III-X* non-man-rated booster (M/R, p. 18, Feb. 15). The estimated total cost of the *Titan III-X* development program is $89 million and the initial $16-million increment includes modification of a launch pad at Vandenberg AFB, Calif., for the new vehicle.

During the development phase, *Titan III-X* vehicles will be assembled and launched from Vandenberg. Associate primes for development will include Aerojet-General, first- and second-stage liquid propulsion systems; Western Electric, radio command guidance; and Aerospace Corp., systems engineering and technical direction.

Outgrowth of Pegasus . . .

Decision Nearing on Cislunar MDS

Preliminary design would be covered by $1-million FY '66 request; hardware might get $3-4 million from reprogramming

SPACE AGENCY OFFICIALS expect to make a decision on the proposed cislunar meteoroid detection satellite within two months.

If approved, the project will move into the preliminary design phase under a $1-million Fiscal Year 1966 authorization request. Hardware development would be initiated by reprogramming other FY '66 funds, if Congress authorized it.

Plans call for putting the satellite into a long elliptical orbit to measure the meteoroid flux before the first U.S. manned landing flight to the lunar surface.

It is an outgrowth of the current Office of Advanced Research and Technology *Pegasus* satellite project, which is gathering data on meteoroids in near-Earth orbit.

Pegasus I was launched by a *Saturn I* booster Feb. 16. *Pegasus B* and *C* are also slated to be launched by the same launch vehicle later this year.

The project is currently under the direction of Milton B. Ames, director of OART's Space Vehicles office, who is bringing together position papers from the Langley Research Center, the Marshall Space Flight Center, the Office of Manned Space Flight, and the Manned Spacecraft Center. These will be coordinated with the results of a study of the satellite by the Martin Co.

- **New hardware probable**—Although the possible use of a *Pegasus* satellite for the mission is being considered, informed sources report that this is highly unlikely. Instead, it is expected that a completely new satellite will be required, featuring improved meteoroid-detection devices as well as sophisticated data-handling and storage and transmission systems.

The cislunar satellite would be launched by the *Saturn IB/Centaur* combination in late 1967 or 1968. It currently is scheduled as the first operational flight for the three-stage vehicle.

The number of satellites in the project will depend in part on the predicted reliability rate for the new launch vehicle—as well as estimates of the meteoroid flux near the Moon.

If the reprogramming action is undertaken, it is estimated that $3-4 million will be needed to begin hardware development.

- **The competition**—Fairchild Hiller is the prime contractor for the *Pegasus* satellite. Its chances of getting the cislunar detection satellite contract will rise or fall with the results of the upcoming *Pegasus* launches. The other major contender for the contract is the Martin Co.

It is expected that the *Saturn IB/Centaur* combination will provide a total payload of about 10,000 lbs., with 3,000-4,000 lbs. being utilized for the cislunar mission.

Another possible mission for the satellite would be to go into orbit around the Moon to measure meteoroids in the lunar environment.

The *Pegasus B* launch is expected to coincide closely with the upcoming *Gemini 4* mission, which could be attempted as early as June 8. *Pegasus C* is scheduled for the third quarter.

Pegasus B was delivered to the Cape on April 17 aboard the "Pregnant Guppy." The two stages of the Chrysler-built *SA-8* are now going through systems tests. Mating of spacecraft to vehicle is scheduled for April 28. ■

International Latex Still in Suit Work

INTERNATIONAL LATEX Corp. intends to stay in the spacesuit business despite cancellation of its subcontract with Hamilton Standard for *Apollo* suit development, an IL spokesman told MISSILES AND ROCKETS.

An IL official said Latex would make proposals to NASA for future spacesuit programs on the basis of the technology built up in early Air Force contracts and the *Apollo* contract. In the future, he said, Latex would ask for fixed-price contracts, based upon confidence that it can write detailed work statements. He said this would put IL in a better position to protect its future investment.

Contrary to some published reports and a statement of a high NASA official, the contract with Latex was not terminated by Hamilton Standard because of "suit/backpack interface problems and radiation and micrometeoroid protection problems." Hamilton Standard officials said that suit/backpack interface problems simply did not exist, and the other two points were not part of the Latex requirement anyway.

HS said the main reason for cancelling the subcontract was problems in shoulder width and mobility. It was an effort to solve these problems that started HS on a new joint design.

Latex said it would attempt to have its suit evaluated at the same time.

International Latex was not part of the original bidding team with Hamilton Standard on the *Apollo* suit, but was given the subcontract by HS at NASA's instruction. Joint design in the Latex version is a route-restrained convoluted bellows, made of pre-formed neoprene.

Under the new contract, B. F. Goodrich has begun fabrication of the five suits which will be used by NASA in evaluation with the David Clark extravehicular suit (M/R, April 19, p. 24). Goodrich, to further confuse the issue, is fabricating the *Gemini* gloves.

David Clark, prime contractor for the *Gemini* suit, has been given the go-ahead from NASA to manufacture spacesuits to be used in early *Apollo* Earth-orbital missions. These will be modified *Gemini* suits, based upon intravehicular *Gemini* suit design. (See *Apollo* spacesuit story, p. 26).

Early next month . . .

Second Project Fire Launch Set

NASA officials seek confirmation of data gathered in first shot to extrapolate re-entry information for manned flight

THE SPACE AGENCY has scheduled its second Project Fire re-entry test for early next month.

Objective of the flight is to validate data received on the *Fire 1* flight last year, which indicated that the Project *Apollo* spacecraft's re-entry will be safe.

The *Fire 1* re-entry package reached a peak speed of 37,890 fps. at an altitude of 400,000 ft. This is well above the *Apollo* re-entry speed of 24,600 mph.

• **Heat measurement**—The objective of Project Fire is to measure the peak re-entry heating, and determine when it occurs during the re-entry trajectory. Although *Fire 1* provided significant data in both areas, the details are classified.

Space agency officials hope that *Fire 2* will confirm the *Fire 1* data, as well as provide data throughout the total 32-min. flight. The one minor technical problem during *Fire 1* was that there was only intermittent information transmission from the re-entry package.

Fire 2 will be the last in the series. NASA, however, plans about five other *Scout* booster re-entry flights in the next two years. It is also looking ahead to a re-entry test program which would make measurements of lifting body re-entry spacecraft.

The launch window for *Fire 2* extends from May 4 to May 8. There is another window later in the same month.

The launch window is required because total darkness at an altitude of 400,000 ft. is required at the re-entry area off Ascension Island in the Atlantic Ocean.

• **Payload & flight details**—The payload consists of the re-entry package built by Republic Aviation Corp. and the velocity package developed by Ling-Temco-Vought and which uses a Hercules Powder Co. Antares II motor. The *Atlas* launch vehicle is built by General Dynamics Astronautics.

The *Fire 2* vehicle will be launched from Cape Kennedy. Flight time will be just over 32 min., including a 21-min. coast period during which the spacecraft will be oriented to the correct entry attitude. Firing of the Antares II motor and payload separation begin about 26 min. after liftoff. Re-entry speed is expected to reach 37,000 fps.

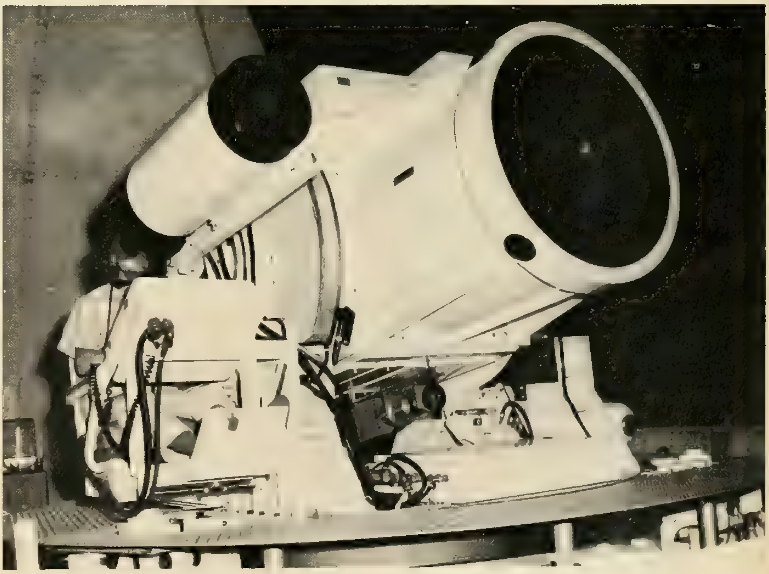
Instruments on the spacecraft, on Ascension Island, and whip and airborne radar and telemetry receiving stations will gather data on the experiment.

• **The spacecraft**—The 20-lb. re-entry spacecraft is a blunt-faced vehicle with a conical afterbody. It is similar to the shapes of manned spacecraft for which flight data at lower orbital re-entry speeds (about 17,500 mph) have been gathered.

The blunt end of the re-entry package consists of three beryllium calorimeters interleaved with three phenolic asbestos ablative heat-protection layers. The first, third and fifth layers are beryllium calorimeters instrumented with thermocouples to provide temperature readings from which the total heating rates will be determined. The second, fourth and sixth layers are heat shields. All but the last two layers will be burned away or jettisoned during the 45-sec. flight through the high re-entry heating period.

Choice of the layer design was dictated by the fact that the calorimeter material—beryllium—will survive only seconds of intense re-entry heat. Hence a series of calorimeters will be used, one during the earliest portion of the re-entry, one when heating rises to a peak, and the third near the end of the heating period. Two of the ablative heat protection layers will be jettisoned at programmed times to expose a fresh calorimeter to the hot-gas region.

Within the re-entry package are three radiometers. Two are single devices to measure total radiant energy and the third is a combination total and spectral radiometer. They will furnish measurements of re-entry heating caused by radiation from the hot gases. ■



TELESPECTROGRAPH on Ascension Island, which will be used for the first time by NASA to track Project Fire instrument package as it reenters the atmosphere at 25,000 mph after ballistic trajectory flight from Cape Kennedy. Instrument has a 36-in.-dia. optical telescope coupled to a very sensitive spectrograph.

At Goddard Meeting . . .

Lunar Surface Controversy Rekindled

Independent interpretations of Ranger data fail to produce agreement about Moon's bearing strength for manned landing

by William S. Beller

GREENBELT, MD.—A head-on collision between two theories as to the nature of the Moon's surface has demonstrated that knowledge in that area remains as it was—virtually nil.

At a recent lunar conference here, one authority maintained that deep dust in the Moon's lowlands might pose serious hazards for venturing astronauts. This was disputed by a second authority, whose calculations indicated that the lunar surface has a very high bearing strength. Each contention was supported with varying degrees of enthusiasm by other conferees.

At the April 15-16 meeting, sponsored by the International Astronomical Union and NASA's Goddard Space Flight Center here, papers were given on the interpretation of *Ranger* photographs, lunar crater formation and surface structure.

Professor Thomas Gold, who has suggested that tiny "fairy castles" of dust lie atop some of the lunar surface, held that the lowlands are blanketed with dust to a depth of a meter or more. He based his findings on radar probes and on thermal data received during lunar eclipses.

Gold, from the Newman Laboratory of Nuclear Studies at Cornell University, Ithaca, N.Y., tied this lunar theory to a supposition that there is a unique transfer mechanism on the Moon that carries dust from the highlands to the lowlands over periods of millenia. He hypothesized an electrical field on the lunar surface of about two volts per centimeter, created by solar radiation. This field, according to Gold, "floats" dust particles downhill.

Gold claimed that an erosion rate of as low as one micron a year would satisfy his concept of dust layers on the Moon.

Asked if he thought the *Apollo* astronauts might be in danger of being swallowed up by the dust, or at least partially buried in it, Gold declared that this was a possibility. He said that if he were on such a flight, and hovering over the lunar suface, "I would not be willing to set (the vehicle) down."

● **Other voices**—Ewen A. Whitaker felt differently, agreeing with the findings in the paper he was presenting for his colleague, Dr. Gerald P. Kuiper, of the University of Arizona's lunar and planetary laboratory. Kuiper concluded that the lunar surface has a bearing strength of between one and two tons per square foot. His calculations, made from data extracted from the *Ranger IX* photographs, are based on the size of rocks ejected from a given impact crater and the distance they traveled.

Professor Harold C. Urey, Nobel Prize-winning scientist and professor of chemistry at the University of California, took a middle road. He would not go along with the Gold dust theory, but at the same time he "worried" about the dimple craters the *Ranger IX* pictures show on the lunar surface. Unrecognized before, these craters are seen varying in diameter from 100 to between 500 and 1,000 ft., and are most numerous in the latter category (M/R, April 12, p. 22). They are rimless, have an inverted bell-like shape, and come down to a flat or pointed bottom.

Urey suggests that the dimple craters were formed by finely divided material on the lunar surface "slumping" into voids or subterranean crevasses beneath the lunar surface. "I'm scared of a manned lunar landing," he told MISSILES AND ROCKETS, "because of the enormous number of slump features *Ranger IX* shows." Tempering his statement, Urey added that the crater Alphonsus, where most of the dimple structures were seen, has more than its share of craters and that the hazard may not actually be as bad elsewhere on the lunar surface.

Dr. Eugene Shoemaker of the U.S. Geological Survey, Flagstaff, Ariz., would not commit himself on the strength of the lunar surface, but said he had no doubt that it was strong enough for a manned lunar landing. The pads of the Lunar Excursion Module (LEM) require a surface able to support one pound per square inch; on the lunar surface, the figure would be reduced to one-sixth that value. "A plastic coffee cup would bear that much weight," Shoemaker said.

At a press conference, when Urey repeated his fear of dimple craters, and Gold nodded agreement, Shoemaker suggested that "not everybody is scared." The geologist, who has volunteered to be a scientist-astronaut, said the dangers in the *Apollo* flight itself are far more significant than any that might be imagined on the lunar surface.

Noting the areas of disagreement, Gold tried in his prepared address to explain why the *Ranger* pictures resolved so little. They are "like a mirror," he said, "each experimenter holding them up and seeing his own theories reflected in them."

● **Conclusions**—Whitaker gave the following "tentative" findings of the University of Arizona's lunar and planetary laboratory:

—The features of the maria come from fluid flows of at-present-unknown substances. (Unlike Goddard scientist John O'Keefe, Whitaker would not pin the flow down to ash—or dust, as Gold would have it.)

—The maria are not completely covered by a layer of (undefined) cosmic dust.

—The entire surface is criss-crossed by linear patterns to make up a grid system. These features are in the highlands as well as in the maria. One group of lineaments run southwest to northeast, another southeast to northwest, and a third bisects the other two and forms a pattern of near-great circles.

This was not a new finding—although the experimenters did add significant details not known before.

—The ridges in the maria are caused by material pushing up from beneath the surface but never breaking through.

—The isolated peaks on the maria are places where the extrusions did break through.

—The rills are almost certainly collapse features.

—Crater rays are thin depths of bright material evenly distributed—not a track of small craters, as some other experimenters would have it. ■

Navy To Build Huge Blast Tube

Facility at Naval Weapons Test Laboratory will be able to reproduce effects of 20-kiloton nuclear explosion

A CONICAL BLAST tube half a mile long will be built by the Navy to simulate a variety of high-altitude blasts and their effects on scale model targets.

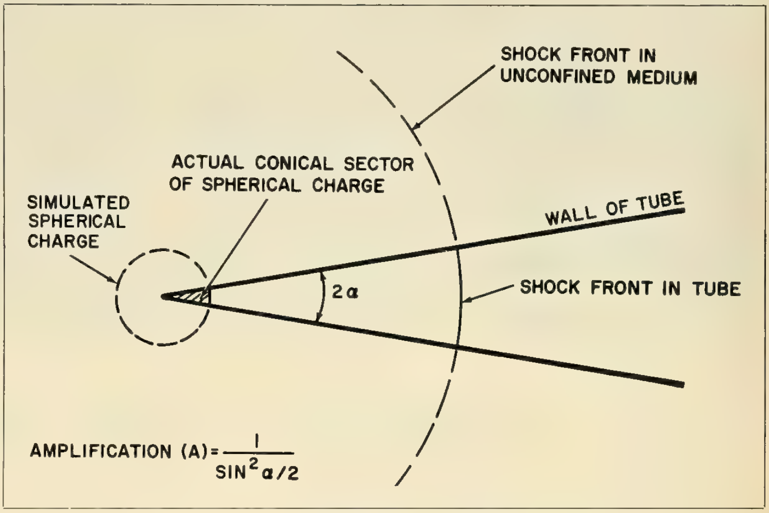
Need for such an experimental facility has been heightened by the provisions of the nuclear test ban treaty forbidding nuclear explosions in the Earth's atmosphere. Work on the simulator is scheduled to begin the end of this month.

Such a facility will provide a technique for studying damage to structures from nuclear blasts without the difficulties of nuclear radiation and without the restrictions of costly tests at geographically remote test sites. Most important, the facility can be operated repeatedly to produce the same type of blast, or a variety of different types of nuclear detonations, and effects can be simulated without loss of the equipment.

The Defense Atomic Support Agency (DASA) has awarded Sun Shipbuilding Co., Chester, Pa., a $2,380,000 contract to build the air blast simulator. The device is designed to reproduce the effects of a 20-kiloton nuclear blast at altitudes up to 100,000 ft., using only a 1,000-lb. conventional high-explosive charge. Sun Shipbuilding will accomplish construction and installation at the Naval Weapons Test Laboratory, Dahlgren, Va.

Overall length of the huge tube, from the face of its 1,900-ton concrete recoil block to the open end, will be 2,447 ft. Inside diameter at the narrow end will be 16 in., enlarging to a 24-ft. inside diameter at the large end. At the apex end of the gradually tapering cone, the steel tube wall will be 1.5 in. in diameter, thinning out to ⅜ in. plate at the open end. To form the detonation chamber, four 16-in. naval guns will be coupled in tandem.

Segments of the long steel cone will be assembled in 100-ft. lengths over its half-mile span. To provide for insertion of instrumented test models of targets, three test stations will be included.


SHOCK FRONT IN UNCONFINED MEDIUM
ACTUAL CONICAL SECTOR OF SPHERICAL CHARGE
SIMULATED SPHERICAL CHARGE
WALL OF TUBE
2α
SHOCK FRONT IN TUBE
AMPLIFICATION (A) = 1 / SIN²α/2

Explosive amplification effect in a conical shock tube.

• **More about the effects**—While the effects of nuclear blasts are already well known both practically and theoretically, much remains to be learned of effects on specific targets, and DASA hopes to acquire the data required from the new simulator, Air Force Lt. Gen. H. C. Donnelly, chief of the DOD agency, said. Scale models used in the test sections of the tube can probably occupy one third to one half of the cross-section area without materially reducing the accuracy of the data through distortion caused by boundary-layer effects, William S. Filler, Naval Ordnance Laboratory physicist said.

He noted that the blast wave in air from a nuclear weapon has a characteristically long duration in its positive pressure phase. At a distance of one-half mi. from a 20-kiloton free-air explosion, the positive duration is about one third of a second. Megaton blasts have positive durations on the order of seconds.

Scientists at the Navy's White Oak, Md., Naval Ordnance Labortaory found that when a small explosive charge is fired in the apex of a cone, the resulting blast wave is closely representative of a sector of the spherical shock wave from a much larger charge fired in the atmosphere. By firing such controlled test explosions in a conical simulator tube, the Navy can acquire scaled test data that closely approximates that gained from a blast in the atmosphere.

Test specimens or models placed in test sections of the tube might include scale-model ship superstructures, dummy missile nose cones, containers, holding jet aircraft engines, electronic gear, or structural members of buildings.

Possibilities of simulating the effects of nuclear blasts on targets floating on water are also being considered. By using the simulator in lieu of actual atmospheric testing, DASA will achieve results and data for only a fraction of the cost of a full-scale atmospheric test. Many of even the most elementary nuclear tests in the atmosphere were performed at costs beginning at about $2 million each—whereas, conceivably a single test with the new simulator might yield similar data for costs beginning at $5,000 per shot.

A pilot facility at the Naval Ordnance Test Station, China Lake, Calif., measuring 180 ft. long, uses a 2-degree cone, whereas the new Dahlgren facility is designed with a 0.6 (plus)-degree cone. ■

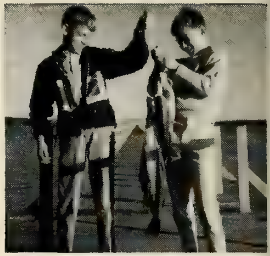
S-IC Static Test Stand

Some test operations

New Orleans French Quarter landmark

Championship golf course adjacent to Pass Christian

Scuba Diving off the Gulf Coast



One of a hundred Bay Saint Louis fishing piers

have all the luck.

Ask any one of the 12,000 men and their families who make up the Gulf Coast aerospace community.

They all made the move. New Yorkers, San Franciscans, men and their wives and children from all over the country. Families who preferred quiet living in a suburban community and families who were used to life in a nerve center. They all came because of the excellent job opportunities which sprang up with this new aerospace industrial community between Gulfport and New Orleans. And they were pleasantly surprised at the excellent living in the area. They discovered that the only difference was not one of outlook, but of backdrop — magnolias and Spanish moss.

Take those who chose to live right on the water in any one of the famous Mississippi resort towns of Long Beach, Pass Christian and Bay Saint Louis. They're living a vacation all year round. Or those who settled in Slidell, Louisiana — a progressive, modern suburb to one of the most sophisticated cities in the U.S., New Orleans (less than an hour's drive from MTO). Then there are the families who make their homes in Picayune, Mississippi where home-town living in a small, friendly community appeals to their tastes.

Professionally they're contributing to some of the foremost space age activities in the country. The *Mississippi Test Operation*, under the aegis of NASA, is the new captive test site for the world's most powerful booster, the Saturn V — *and its successors*. General Electric is the prime support contractor for NASA at MTO and will operate and supply both the technical and plant support for all propellants and gases, data reduction, data acquisition, electronic and instrumentation laboratory, central control, meteorology laboratory, acoustical laboratory, facilities engineering and utilities, and all logistics functions.

Professional opportunities now open: Engineers-Electronic/Communications (BSEE) ☐ Engineers-Cryogenic Liquid and Hi Pressure Gas Equipment (BSME) ☐ Engineers-Instrumentation Systems Design (BSEE) ☐ Engineers-Cryogenics (BS in M.E., Chem. E., or Petroleum E.) ☐ Specialists-Cryogenic Test Stand ☐ Engineers-Electromechanical (BSEE or Physics) ☐ Project Engineers-Mechanical and Test Equipment (BSME) ☐ Engineers-Test Stand Control System (BSEE) ☐ Project Engineers-Systems, Cryogenic Barges (BSME)

If you want to share in the "luck," check to see if your experience fits any of the openings; then write us: Mr. Frank F. Oppedisano, Professional Selection & Placement, General Electric Co., Mississippi Test Support Operation, Room **94-T**, *Bay Saint Louis, Miss.*

Mississippi Test Support Operation
MISSILE & SPACE DIVISION

GENERAL ELECTRIC

An equal opportunity employer.

Technical Countdown

ELECTRONICS

New Frequency Stability Calibration at NBS

The frequency stability calibration of precision signal sources in the range from very low frequences to 500 MHz is now a regular service at the Radio Standards Laboratory, Boulder, Colo., facility of the National Bureau of Standards. The equipment is capable of accuracy in the one part in 10^{10} category. Additional facilities will provide similar calibration services to 1,000 MHz. Signal sources submitted to the lab should provide a minimum power output of 10 milliwatts—into a matched load—and have a frequency stability better than one part in 10^7. The calibration consists of measurements of both long-term (greater than one day), and short-term stability.

TV Data Transmission To Be Set Up Within NASA

Digital data generated during launches at Cape Kennedy will be viewed and monitored by scientists at NASA's Marshall Space Flight Center, Huntsville, Ala., through a television console system. Now being installed by Stromberg-Carlson Corp., the system will transmit data from a Burroughs B-5000 computer. Pre-launch and launch operations information will be routed via telephone lines to the computer and then into the TV system's buffer and two display generators. The generators convert digital computer codes into alphanumerics and graphics. The graphic information will be displayed on the face of a special cathode-ray tube. Infrequently changing data such as grids or forms will be copied on slides which can be superimposed by a projector on the changing digital information. Two simultaneous displays can be presented on each tube face and a closed-circuit TV camera sends information to Marshall. The system is designed for the expected increase in *Saturn* rocket launch activity.

Ship-Borne Apollo Radar Contract Let

Dynamics Corp. of America's Reeves Instrument Division will develop and build two radar tracking antenna systems designed to track the *Apollo* spacecraft from ships at sea. The $1-million contract covers two 12-ft.-dia. reflector dish antennas, pedestal, drive and control systems. These and three other 30-ft. models previously ordered from Reeves by NASA will be incorporated into the unified S-Band Systems. Each of the five antenna systems will be mounted aboard five ships forming part of the world-wide *Apollo* tracking and communications network.

Surveyor Power Deficit Reduced

Consumption of too much electric power by systems on *Surveyor* has led Hughes Aircraft Company, the prime contractor to Jet Propulsion Laboratory, to modify a number of circuits on the lunar spacecraft. A square-wave power supply will now replace the three-phase sine-wave power supply in the flight-control electronics unit. This reportedly will trim the spacecraft's power deficit by some 600 watt-hours. Redesign of flight-control electronics now is needed because of this change.

MATERIALS

Shape-Retaining Expandables Perfected

Seam-bonding two identical flat patterns of aluminum foil and then inflating bonded assembly to a wall stress slightly above the allowable foil yield results in a structure in a state of permanent set. Engineers at Avco's Research and Advanced Development Div. have proven that the expandable structures thus generated will retain their shape even after puncture and escape of the pressurizing gas. The process develops the highest stiffness-to-weight ratio of any known structural material, Avco/RAD claims. For specialized applications requiring additional strength, the firm has developed a cartridge which fills the depressurized internal volume of the expanded structure with a lightweight urethane foam.

Synthetic Emeralds Created at NOL

Synthetic emeralds of gem quality can be created in two minutes through a high-temperature, high-pressure technique developed at the Naval Ordnance Lab, White Oak, Md. The clear crystals are formed directly from beryl powder in far less time than required by comparable processes such as the hydrothermal flux or flame-fusion methods. Wayne Wilson and Hubert Hall, co-inventors of the NOL process, claim that the color can be controlled by substituting various amounts of metallic oxides—particularly chromic oxide—in the beryl powder. The NOL crystals are attracting attention in the semiconductor field because of the maser characteristics of emeralds.

Thin Film X-Ray In Situ Analysis Possible

Quantitative and qualitative measurements of thin films during and after deposition will be possible with a new instrument marketed by Materials Research Corp., Orangeburg, N.Y. Developed by the firm under an exclusive license with the Franklin Institute, the device is an X-ray diffractometer attachment. The unit will permit highly accurate X-ray intensity measurements at very specific angles of incidence with respect to the thin film under examination. Observations are possible over the complete angular range normally used on standard X-ray diffractometers. Two units will be available in May, allowing observations at 10^{-7} and 10^{-9} torr respectively.

Self-Propelled Hand Tool Being Developed

A side effect of attitude control efforts at Vickers, Inc., division of Sperry Rand Corp. is being funneled into a hand-operated, bipropellant powered tool. The device, called PLANETool, can be adapted by changing the tool head to operations such as welding, cutting and hammering as well as boring for geological samples. The tool, aimed at both lunar and ocean-bottom operations, is powered by burning two liquid propellants in a combustion chamber mounted on the handle. Quick-disconnect cartridges, each holding five minutes worth of propellants, can be carried easily on the operator's belt. The high-temperature gases (5,500°F) produced in combustion drive a small 100,000-rpm turbine connected through reduction gearing to the tool. Final tool speed is 2,000 rpm.

Tape-Wrapping Technique Refined

Haveg Reinhold technology could yield parts with greater uniformity than present compression-molded members

by John F. Judge

A HIGHLY AUTOMATED, controlled tape-wrapping process developed by Haveg Reinhold, Inc., may lead to the fabrication of large nozzle and nose cone components on a reliable, uniform production basis.

The in-house program focused on the many variables in tape wrapping—including the raw material and environmental factors—and, coupled to the design of new wrapping machines, led to the production process.

Sam Salzinger, special projects manager, says the program was designed to achieve the highest "as wrapped" densities possible for any given material and for both bias and warp tapes.

The process has been viewed with some enthusiasm by major propulsion and airframe prime contractors. Tape-wrapped components have generally exhibited better resistance to erosion, greater reliability and uniformity than compression-molded units, says Salzinger.

The major programs in which such a route to ablative components and assemblies is being used include the *Polaris A-3, Minuteman II, Titan II* and *Titan III* and the large solid booster program. The 120-in. strap-ons for the *Titan III-C* recently shifted from monolithic graphite to wrapped processes.

Salzinger defines tape wrapping as the application of sheet materials, woven or non-woven and generally pre-impregnated with resin, to a rotating mandrel, circular in cross section. The application is made at a specific and controlled orientation relative to the mandrel centerline.

The quality of a tape-wrapped part is a direct function of the control of tape orientation during the wrapping and maintenance of that orientation during the high-pressure cure.

To achieve this, the tape must be applied to the mandrel so that maximum compaction results and maximum density in the "as-wrapped" condition is realized. After wrapping, the tape-wrap mandrel is subjected to heat and pressure to produce the final part.

● **Material control crucial**—A critical part of the tape-wrap process developed at Haveg Reinhold is material control. Once the specific material is defined for the process, any major variation of resin content, degree of polymerization, and volatile content within the tape roll or from roll to roll will affect the final result. Better definitions of allowable material variations are being achieved, using tools such as infrared analysis. Modifications of this new tape-wrap process are being studied, with some success, to reduce the effect of inherent variations in the material.

During the cure, variations in moisture content may result in blistering and de-lamination, excessive flow variation and/or density variations.

Recognizing these problems, Haveg Reinhold established a large tape-wrap facility with temperature and humidity controls. The environment in the 10,800-sq.-ft. building is controlled continuously at 73°F ± 2°F and 45% ± 5% relative humidity.

Tape materials are stored in this building before use so that the material is uniformly conditioned at this environment prior to wrapping.

Variables in the wrap process include tape tension, compression roller pressure, tape temperature, cooling and tape speed. To properly balance these variables and reduce the effect of the operator, new tape-wrapping machines have been built that will automatically control the variables during the actual tape-wrapping operation.

Tape temperature, cooling and degree of advancement of impregnated material are directly and closely related. They could be summed up as tack temperature of the tape. For a specific degree of resin advancement, there is a minimum tack temperature required to insure positive tack or adhesion throughout the wrapping sequence.

● **Adhesion considerations**—Positive adhesion is of prime importance. Failure to achieve good tack for even a part of one revolution may mean that the wrapped part may separate or slide at that point during the wrap operation, or during handling prior to application of final cure pressure. This can cause successive ply separation, loss of control of orientation and de-laminations in the final part.

Since resin advancement is a function of both temperature and time, it is possible to expose the tape to high temperatures (for tack) for a short time (by cooling rapidly) without noticeably affecting resin polymerization. Haveg Reinhold has proven this by measuring resin flow and advancement before and after wrapping and has not noticed any change within the accuracy of the tests performed.

The firm has found that the highest as-wrapped densities for standard phenolic (MIL-R-9299) impregnated materials are obtained by using advanced materials with minimum tack temperatures above 230°F. This is true for both parallel (warp) tape and bias tape wrapping.

Compression roller pressure—a prime element in the process—should exceed 100 lbs. per inch of width for these advanced materials. For less-advanced materials, lower pressure should be used to prevent crushing or damaging of the fibers. The more highly advanced tapes have elevated temperature resin viscosities—high enough to act as a protective cushion for the fibers.

Under these conditions, high pressure may actually increase tape tensile strength significantly. No advantage is seen by Salzinger in increasing the pressure beyond 250 lbs./in. of tape width.

● **High density necessary**—High as-wrapped density is the key to a successful tape wrapping process. High as-wrapped densities automatically result in minimum wrinkles, maximum cured densities, good control of orientation, and therefore, reproducibility.

As an example, using carbon and graphite bias tape, Haveg Reinhold consistently achieves an as-wrapped specific gravity of 1.35 to 1.36. Based on a cured specific gravity of 1.47, the as-wrapped density is about 92% of final.

Under these conditions of wrapping, lower pressures (less than 1,000 psi) can be used for final cure. In fact, Haveg Reinhold is producing bias-wrapped parts of silica/phenolic which, cured at autoclave pressures of 200 psi, result in finally cured gravities of 1.76 to 1.80 (essentially maximum attainable for 32% resin solids, unfilled and unmodified phenolic resin).

These gravities are usually associated with hydroclave cure pressures of 1,000 psi or higher, and are attainable at lower-pressure cures only if the part had been wrapped to a high density level.

- **Parallel wrapping**—Tape wrapping parallel to the centerline is a straightforward process. High tape tension results in high compaction and good guiding control. Parallel wrapping with warp tape is generally restricted to exit cone liners, throat and blast-tube back-up insulation, and some specialized insulation.

For re-entry nose cones, combustion chambers for liquid rockets, convergent or entrance sections of rocket nozzles, ablative throats, external insulation and some exit cones, some significant angle to the centerline is desirable or required. These will vary from 4° all the way to 70° to the centerline, depending on the performance requirements.

Bias tape is used to obtain these angles. The optimum form is a tape cut on a 45° bias, supplied in continuous rolls slit to the desired width. Splices every four feet or so are needed to provide a continuous tape.

- **Angle wrapping**—Bias tape is used when an angle orientation is required, because the tape must deform as it is wrapped. There is a limit beyond which the tape will not deform properly. When this limit is reached, the tape starts to wrinkle, pucker or tear. This limit can be shown as a function of the geometry of the wrap.

The edge of the tape in contact with the mandrel is supplied at a slower rate than is the outer edge of the tape because of the difference in circumference. This difference in speed (or actually difference in circumference from edge to edge) requires the tape to stretch across its width, with the maximum stretch at the outer edge. The ability to do this is a function of the ratio of minimum and maximum circumferences, where W = bias tape width.

The minimum circumference is πD. The maximum circumference is $\pi(D+2h)$. The ratio of maximum to minimum circumference is therefore:

$$\frac{\pi\,(D+2h)}{\pi\,D} = \frac{1+2h}{D}$$

Since h = W sine 0 Salzinger says, it is obvious that the ability to bias wrap is a function of the tape width, orientation angle and diameter.

Haveg Reinhold uses a simple ratio to analyze bias wrapping.

$$\text{Reinhold Wrap Ration (RRR)} = \frac{D}{H}$$

The lower the RRR, the more difficult it is to wrap the tape. It is readily seen that for large diameters, for a given tape width and angle (constant h), the bias tape will be easier to apply. If the width and/or angle are large, the wrap will be more difficult or even impossible.

Until recently, the lowest RRR in industry has been about 5:1. This means, for example, that if the diameter is 10 in., and the angle of wrap is 30° to the centerline, then:

$$h = W \text{ sine } 30°$$

$$\text{and } 5{:}1 = \frac{D}{h} = \frac{10}{W \text{ sine } 30°}$$

$$\text{or } W = 4 \text{ in.}$$

and the maximum width of continuous bias tape that could be wrapped successfully is 4 in. This has been the limit for the existing equipment and processes, which, in the main, have been hand operations and dependent on the operator.

When this limit is reached on a given part, the use of continuous bias tape must be discontinued, and the operator must resort to patterns.

These patterns must be hand-fed onto the mandrel.

- **Machine progress**—Haveg Reinhold developed new concepts for continuous bias wrapping and has built wrapping machines that are capable of wrapping to much lower RRR ratios. For example, the firm has completed a series of re-entry cones that are about 37 in. max. dia., 6 ft. long, and 6 in. min. dia. with a half angle of 12°, using 4½-in.- and 5 in.-wide continuous bias silica/phenolic tape, wrapped at 30° to centerline. At the large end, the RRR is high and the wrap is fairly easy. At the smallest diameter, the actual RRR achieved (without any wrinkles or puckers) was 2.4:1. Salzinger claims this is a major improvement over previous wrapping procedures.

A series of test samples was made to find the actual limit of the equipment. On a 2.75-in.-dia. cylindrical mandrel, 3-in.-wide silica/phenolic, carbon/phenolic and graphite/phenolic bias tapes were successfully wrapped at 35° to centerline. The RRR ratio was 1.6:1.

The as-wrapped specific gravity of the above samples were:

	as-wrapped	% of final Sp. Gr.
Silica/phenolic	1.60	91.5%
Carbon/phenolic	1.36	92%
Graphite/phenolic	1.35	93%

Another test was made using a 9.0-in.-dia. mandrel and 4.5-in.-wide silica/phenolic bias tape, successfully wrapping at 67° to the centerline. A completely wrinkle-free part was achieved, and the limit ratio was: 2.17:1.

The as-wrapped specific gravity was 1.58 and the part was cured at 200 psi autoclave pressure. The cured specific gravity was 1.73, which means that the wrap was excellent (91% of final density). This test proved that the RRR is valid, even for extreme angles of wrap, says Salzinger.

Additional improvements in bias wrap techniques will further reduce the RRR. Salzinger says it would be theoretically possible to wrap the following:

Angle	Tape Width	Min.Dia.
60°	5 in.	7 in.
30°	10 in.	10 in.
15°	5 in.	2 in.

- **Tests show adaptability**—Further tests have been made to determine the feasibility of changing the wrap angle, during wrapping, to effect a varying orientation in a given part to meet certain design criteria and performance requirements. The Haveg Reinhold bias-wrap machines are designed to continually and uniformly change angle during wrapping.

In one test, made on the 9-in. mandrel, the orientation angle was successfully and continuously changed from 67° to 45° over a distance (height of wrap) of 3 in. This means that a rate of transition of about 7°/in. was achieved, using 2.5-in.-wide bias tape. Further studies are being made to determine the limit of angle change and the effect on final density.

With these high as-wrapped densities, good orientation control and high final densities are achieved. Intermediate debulking operations for composites may be omitted.

- **Versatile machines**—The Haveg Reinhold continuous-bias wrap machines have some additional advantages beyond the ability of wrapping high-density bias parts at extremely small RRR ratios. Bias tapes, when heated for tack, will normally "neck" in width (decrease) 10-20% during wrapping. This means that larger widths are required as overstock on the outside diameter to meet part thickness requirements.

Variable necking also results in very irregular outside diameter surfaces which normally require some outside diameter machining before applying cure pressure. All these problems result in higher material consumption, and therefore higher costs.

These new bias machines will wrap 5-in. tape with a maximum necking of 0.25 in. and an average of 0.125 in. This means that necking will range from 2.5 to 5%, with very little variation, resulting in a uniform outside diameter surface and less waste of material. It is now possible to predict the tape widths more accurately, resulting in lower overall costs.

Another major advantage of this new bias equipment is that it is almost completely automatic. ■

ANOTHER ASPECT OF THE MARQUARDT MISSION

Marquardt Broadens Rocket Systems Capability

New Space Engine Laboratory Cited as Important Propulsion Milestone

When Marquardt dedicated its new space engine propulsion laboratory at Magic Mountain near Van Nuys, California, the completion was cited as "an important milestone in the Project Apollo program." Startup of operations at Magic Mountain now marks another significant extension of Marquardt's rocket system management capability.

MISSION-MATCHED FACILITIES

At the new space engine facility, Marquardt engineers are testing reaction control rockets and propellant systems for the Apollo Lunar Excursion Module. Advanced high energy fuels, including fluorine-based propellants, are also being handled at Magic Mountain to meet a broad range of future mission requirements. The Marquardt Jet Laboratories accommodate extensive environmental testing for airbreathing propulsion systems and rocket components. In addition, tests are being conducted at another Marquardt Research Field Laboratory for advanced propulsion and hypersonic regimes. The combined capability of Marquardt's facilities now provides testing of advanced aerospace systems, components, and fuels from sea level to above 185,000 feet.

MISSION-MATCHED TECHNOLOGY

Today, Marquardt is demonstrating its ability to assume rocket systems management responsibilities from concept to hardware. In meeting mission requirements, the company has documented many technological achievements on such programs as Advent, Syncom, the Project Apollo Service Module and Lunar Excursion Module, and the new Lunar Orbiter Vehicle. For example, Marquardt engineers were first to apply film-cooling techniques to radiation-cooled reaction-control rockets, utilizing fuel as a film coolant. Marquardt has also demonstrated several techniques for operating radiation-cooled engines with a secondary cold exterior wall, allowing application of such engines in submerged configurations on a spacecraft.

ADVANCED MANUFACTURING SUPPORT

Marquardt has implemented high precision manufacturing techniques, tooling, and reliability procedures in support of rocketry. Spin forged rocket cases, sophisticated ballistic missile nozzles, thrust chambers, propellant controls, and tanks are products of these modern methods. New contamination-free clean rooms assure the environment necessary to meet the stringent demands of aerospace requirements.

MEETING NEW CHALLENGES

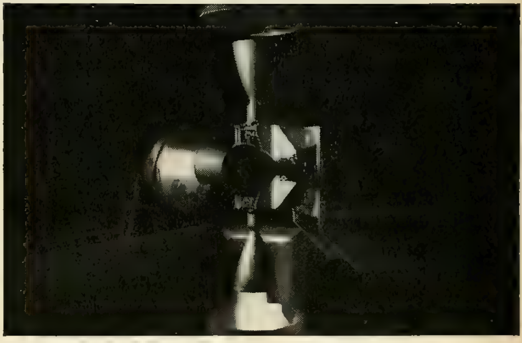
Marquardt's quest for solutions to new problems is typified by efforts directed at future manned vehicle, satellite, and ballistic mission applications. Already pursuing studies on the Apollo-X, Marquardt is conducting extensive research on hydrogen-oxygen ignition, high density-high performance propellants, pyrolitic graphite and other high temperature materials, advanced cryogenic gels and slurry fuels.

BALANCED CAPABILITY

Its work in the field of rocketry is but one aspect of the Marquardt mission. The company's engineering, manufacturing and facility complement is applied vigorously to support other major aerospace activity in airbreathing propulsion, space equipment, electronics, advanced research, specialized manufacturing, and industrial products. For information concerning the scope of Marquardt operations, write to J. B. Montgomery, President, The Marquardt Corporation, 16555 Saticoy Street, Van Nuys, California.

Engineers and scientists experienced in these or related fields will find it rewarding to discuss career opportunities with Marquardt, an equal opportunity employer.

MARQUARDT ENGINEERS discuss status of reaction control rocket engine program in PERT meeting.



LEM ROCKET CLUSTER undergoes test firing at Marquardt's new Magic Mountain space engine laboratory.

EXPANDED CLEAN ROOM facilities assure environment to meet the stringent aerospace requirements.

THE Marquardt
CORPORATION

CORPORATE OFFICES, POWER SYSTEMS
DIVISION, ASTRO—VAN NUYS, CALIFORNIA
POMONA DIVISION, INDUSTRIAL PRODUCTS DEPT.
—POMONA, CALIFORNIA
OGDEN PLANT—OGDEN, UTAH
SUBSIDIARY: AUTOMATION LABORATORIES INC.,
MINEOLA, L.I., NEW YORK

Circle No. 4 on Subscriber Service Card

Apollo Suit Substantially Redesigned

New garment has reduced volume, allows astronaut greater mobility and comfort than earlier designs; helmet also altered

by Heather M. David

WINDSOR LOCKS, CONN.—Improvements in spacesuit design have led in the past six months to a complete change in thinking about the *Apollo* suit.

Almost every detail of the suit itself —except the water-cooled thermal control system and basic environmental control system—has been redesigned in an effort to get around some of the restrictions of spacesuit use. Spacesuit program managers at Hamilton Standard Div. of United Aircraft, which has the prime contract for the *Apollo* extravehicular mobility unit (EMU), told M/R that work conducted there in the last half-year or so has produced these results:

—Complete redesign of joints, using a new technique which has increased mobility while decreasing the amount of effort the wearer must exert to move the pressurized suit. In addition, joints have been installed in the wrists and ankles.

—Minimization of leakage points by redesign of neck openings, gas connection points and other features.

—Increased comfort to the wearer, through better fitting and decreased bulkiness.

—Decreased volume. Shoulder breadth, for example, has been reduced by approximately 4 in.

Five new suits incorporating new design features worked out at Hamilton Standard are being fabricated by B.F. Goodrich Aerospace and Defense Products Group of the B.F. Goodrich Co., the same group which was prime contractor on the *Mercury* pressure suits. Hamilton Standard recently terminated its contract with International Latex Corp. for this responsibility.

The new suits will have a face-off with the David Clark extravehicular *Gemini* suit in June, when NASA will conduct evaluations of the two versions for *Apollo* use. Although Hamilton Standard will retain total systems management control, the Phase II contract conceivably could contain practically any combination of subcontractors.

The most obvious change in the suit is the absence of the familiar silver-white color of the suit—the color which was utilized in the *X-15* and adopted for *Mercury* and *Gemini*. However, since this will be further covered by an outer thermal protective garment, for extravehicular use, there is no requirement for reflective material to be used in the *Apollo* suit.

The present outer covering of the Hamilton Standard suit is a flashy light-blue. The color has no functional purpose, and, as a matter of fact, the only reason this layer is necessary is that NASA has classified some of the inner workings of the suit.

- **Joints**—Design of the new joint arrangement was begun in Hamilton Standard laboratories some months ago. Motivation was a desire to cut down shoulder width. Since the center seat of the Command Module will now be fixed in place rather than folded down, space will be at a premium during periods that all three pilots must be in the pressure-suit mode.

Shoulder width has been decreased from approximately 27½ to about 23 in. It also was considered desirable to reduce the width of the elbow, since it must fit on an arm rest during certain periods.

The joints are formed by a series of folds in excess material at the joint area. The exact arrangement is classified, but it can be reported that multiple suspension cords are arranged to bridge the gap across the joint to take axial loads during pressurization. Also taken into account are surface area changes, which are based closely upon the skin-surface area change which occurs when a human moves his own body.

The design permits omnidirectional flexing. In addition, there are unlimited "neutral" positions. The astronaut will be able to hold his arms above his head, for instance, without applying torque to hold the position. This could be an important factor if repair work must be done, Hamilton Standard engineers point out. In most previous spacesuits, effort had to be exerted to hold almost any position except arms down.

Another feature of the joint arrangement is that the astronaut may move completely naturally. For example, he may move his arm directly from one point to another without going through intermediate points imposed by suit design.

Motion range has been improved considerably. In the current pressurized garment, these improvements in range have been demonstrated:

—Shoulder elevation from 90° to 140°.

—Shoulder transverse rotation increased from 72° to 120°.

—Voluntary unpressurized sagittal elevation increased from 75° to 143°.

—Voluntary pressurized sagittal elevation increased from 42° to 110°.

—Voluntary unpressurized transverse rotation increased from 99° to 150°.

—Voluntary pressurized transverse rotation increased from 98° to 120°.

—Pressurized "elbow in" width about 1½ in. less.

In the unpressurized state, the suit fits more like a cloth garment, since the joints do not have the bulkiness of the bellows arrangement.

The new joint design has been extended to the wrist and ankle, which had never been articulated before. Although the wrists have had some attention, no satisfactory solution had been achieved.

- **Torso**—Previous designs for the *Apollo* suit were based upon the philosophy that one basic size should fit as many astronauts as possible. Some provision was made for adjusting arm, leg and torso length.

However, Robert Breeding, EMU program manager told MISSILES AND ROCKETS it has been decided to provide custom-fit torsos for each suit. This has the advantage of decreasing bulk and increasing comfort. But the most important effect is that on mobility. By precisely locating the joints, maximum mobility can be obtained.

The three suits now being designed are tailored for astronaut Mike Collins, project engineer Jerry Goodman, and test subject Jack Slight.

Improvements are also being made in the suit entry closure. Unlike *Mercury* and *Gemini* suits, the *Apollo* suit entry is made through a neck opening,

He's never out of touch.

The modern Apollo has EVSTC—Extra-Vehicular Suit Telemetry and Communications.

Once out of the Lunar Excursion Module, EVSTC will keep him in voice communication, relay his respiration rate, temperature, pulse, and space suit pressure back to his spacecraft. Instructions relayed back through LEM will automatically control his suit environment.

Back on Earth—where EVSTC was provided by an ITT company—the ITT System will be coming up with more communication ideas for further interplanetary exploration and manned space stations.

ITT developments in microelectronics have already lent themselves to advances in extraterrestrial hardware. The low-cost Army geodetic satellite, built by ITT, is a good example.

An ITT-developed transportable ground station was the first of its kind to be compatible with NASA's Relay and Syncom satellites as well as Telstar.

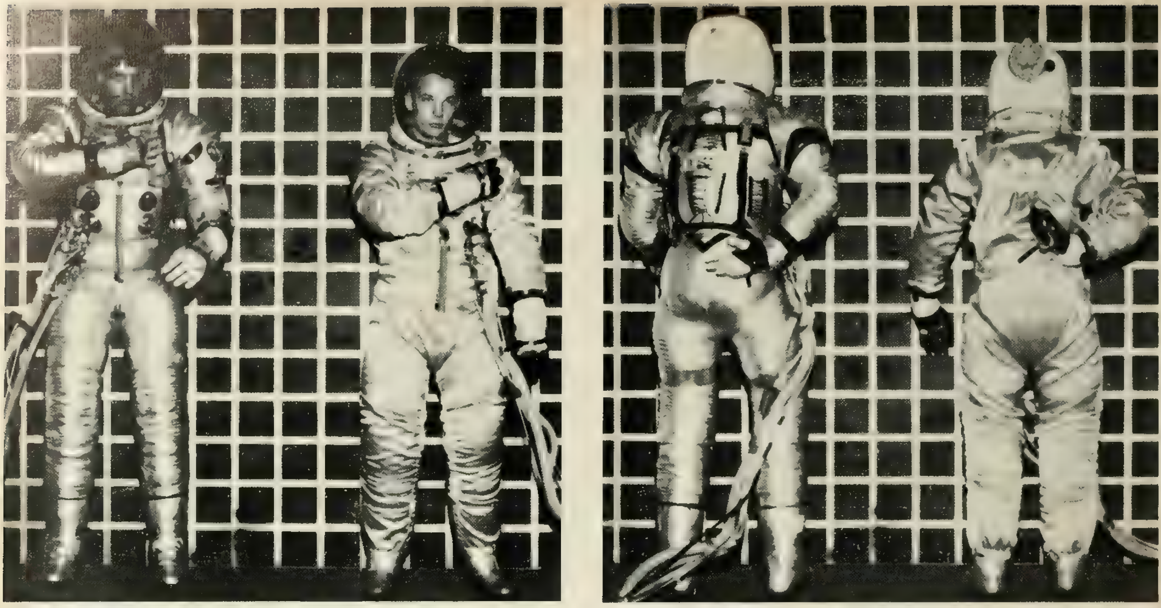
Lasers, infrared, optical sensors and gas bearing gyros for inertial guidance systems are but a few of the areas of advanced development that have made ITT the world's largest international supplier of electronic and telecommunication equipment.

International Telephone and Telegraph Corporation. World Headquarters: 320 Park Avenue, New York, New York 10022.

THESE ITT COMPANIES ARE ACTIVELY SERVING U.S. DEFENSE AND SPACE PROGRAMS: FEDERAL ELECTRIC CORPORATION • ITT CANNON ELECTRIC DIV. • ITT DATA AND INFORMATION SYSTEMS DIVISION • ITT ELECTRON TUBE DIVISION • ITT FEDERAL LABORATORIES • ITT GENERAL CONTROLS DIV. • ITT GILFILLAN INC. • ITT INDUSTRIAL LABORATORIES DIVISION • ITT INDUSTRIAL PRODUCTS DIVISION • ITT KELLOGG COMMUNICATIONS SYSTEMS • ITT SEMICONDUCTORS, DIV. ITT WIRE AND CABLE DIVISION • ITT WORLD COMMUNICATIONS INC. • JENNINGS RADIO MANUFACTURING CORPORATION

ITT

Circle No. 5 on Subscriber Service Card



FIRST PHOTOS of redesigned Apollo spacesuit (worn by subject at right in each photo) show the greater freedom of movement it allows compared to earlier design. More rigid joints of earlier suit restricted wearer's reach.

rather than zippers crossing the torso. While the basic gusset design of some months ago has been retained, Hamilton Standard is now working on a single-flap arrangement to simplify the handling and minimize leakage points, J. Calvin Beggs, assistant program manager, said.

The gusset design, similar to that in a man's Arctic boot, ensures that no pressure is lost even if the zipper or fastening is loose.

There is no neck dam on the helmet, although Hamilton Standard will look into provision for water immersion after landing.

• **Helmet**—A study was begun last summer on a fishbowl helmet design to replace the conventional closed helmet. The new configuration was decided upon last fall and "work suits" supplied to NASA now incorporate this fishbowl design.

Beggs reported that the new design provides increased reliability, since it eliminates the visor seal and rotating neck ring in favor of a simpler arrangement. It is expected to be more comfortable as well, since the astronaut's head will not be restrained. Greater visibility also will result.

Present impact protection is much the same as in previous models, with the wearer's head in a "bump hat" inside the helmet. However, work is now progressing toward an arrangement which would be built into the wall of the helmet itself.

• **Visor**—It now appears that a primary and secondary visor coated with special optical coatings will be furnished. Coatings have now been developed which transmit only about 10% of the total ultraviolet spectrum, with about 30% being reflected and the remaining 60% being absorbed.

However, Beggs said the final visor configuration should have no UV transmission, since the visor material probably will be polycarbonate rather than the Plexiglas substrate used to test the coatings.

In the visible frequency band, about 83% of the light energy can be reflected by the coatings currently developed. In the near-infrared frequencies, about 65% is reflected, with about 80% reflected in the far IR range (dividing line being about 3 millimicrons).

Beggs said that by using a coated inner visor on the cold lunar night operation, a temperature of about 75° can be maintained on the inner visor surface where frosting might occur from the moisture in the ventilation air. A secondary visor with other special coatings would be used during the full subsolar lunar day.

• **Boots and gloves**—Boot design has been changed completely from the rather hard boot construction to an all-soft construction for more flexibility in walking. Former material was leather. The present design calls for a fabric top like that of the rest of the suit, with special soles.

Gloves also have been improved for gripping capability.

• **Thermal and micrometeoroid**—Early designs postulated a thermal overgarment made of reflective materials encasing the entire spacesuit and backpack assembly. Micrometeoroid protection was considered a separate problem. Although data were sparse, some consideration was given to a hard cape or umbrella-like protective covering.

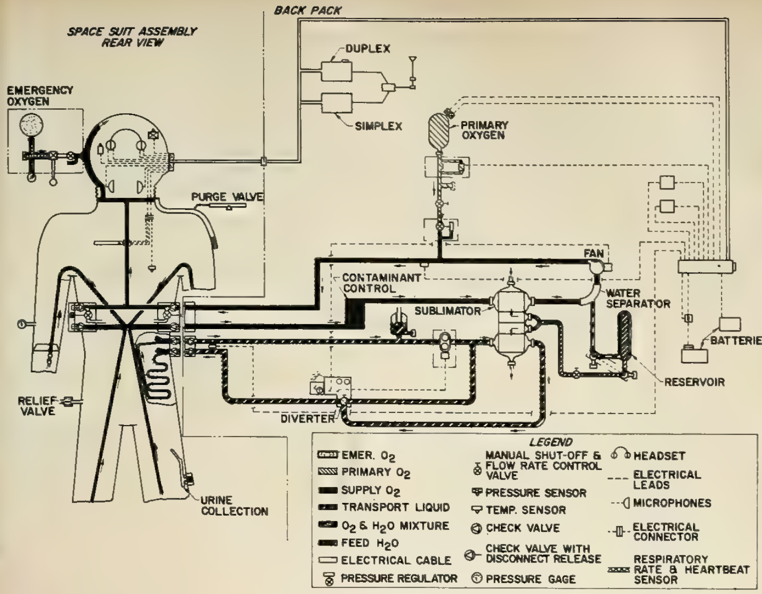
However, revised estimates on the flux have changed thinking so that it now appears that a multi-layered covering made of flexible materials might suffice. This may be incorporated into one single, multi-layered garment which would be donned for both thermal and micrometeoroid protection.

• **Gas disconnects**—Improvements also have been made in the functional connections between backpack and suit. Originally, there were two separate connections for gas system entry and exit. These fittings, measuring as much as 4½-in.-dia. apiece, were bulky and difficult to engage and, since they were placed upon the wearer's chest, interferred with movement of the arms.

The connects have been placed one inside the other, so that both exit and entry are on the same axis. This arrangement, which measures only 3 in., also reduces the possibility of external gas leakage.

• **Emergency oxygen**—In addition to the portable life support system (PLSS) which fits on the *Apollo* astronaut's back, he will be provided with an emergency oxygen supply on the back of his helmet.

This will furnish the astronaut with enough oxygen—should he have a serious leakage such as that occurring if a relief valve failed to open—to get back to the Lunar Excursion Module. This failure mode—chosen as an example of


SPACE SUIT ASSEMBLY REAR VIEW
BACK PACK
EMERGENCY OXYGEN
DUPLEX
SIMPLEX
PRIMARY OXYGEN
PURGE VALVE
FAN
CONTAMINANT CONTROL
SUBLIMATOR
WATER SEPARATOR
BATTERIES
RESERVOIR
RELIEF VALVE
DIVERTER
URINE COLLECTION
LEGEND
EMER. O2
PRIMARY O2
SUPPLY O2
TRANSPORT LIQUID
O2 & H2O MIXTURE
FEED H2O
ELECTRICAL CABLE
PRESSURE REGULATOR
MANUAL SHUT-OFF & FLOW RATE CONTROL VALVE
PRESSURE SENSOR
TEMP. SENSOR
CHECK VALVE
CHECK VALVE WITH DISCONNECT RELEASE
PRESSURE GAGE
HEADSET
ELECTRICAL LEADS
MICROPHONES
ELECTRICAL CONNECTOR
RESPIRATORY RATE & HEARTBEAT SENSOR

SCHEMATIC DIAGRAM of Apollo space suit being fabricated for Hamilton Standard Div., United Aircraft Corp., by B. F. Goodrich Aerospace and Defense Products Group.

a serious but extremely unlikely occurrence—would require the emergency oxygen to be supplied at such a rate that it would last approximately five minutes. For less serious leakages, it could last as long as 1½ hours, Hamilton Standard engineers said.

Design of this unit also has been modified and improved. In earlier concepts, the unit had two pressure regulators between the 7,500-psi storage tank and the 3.5 psi of the suit operation. It was found that one of the regulators could be discarded, and the round storage tank was modified into a doughnut-shaped tank with the pressure regulator in the middle. This unit fits neatly on the back of the helmet. It carries ¼-lb. of oxygen at 7,500 psi.

- **PLSS**—Detailed design activity on the backpack unit—which carries both the thermal control and oxygen supply for breathing—has been progressing at Hamilton Standard during the last few months. Four sets of hardware are now 95% complete, according to Freeland Savage, PLSS project chief.

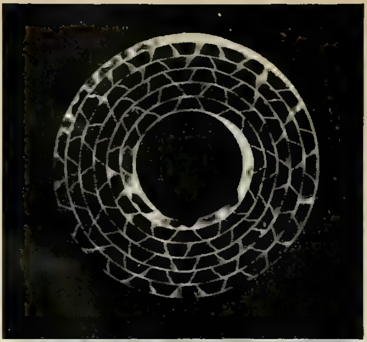
The backpacks, tailored to fit the torso and rounded so that there is no danger of the astronaut having difficulty rolling over should he fall on his back, measure 24 in. high, 16 in. wide, and are about 7 in. deep.

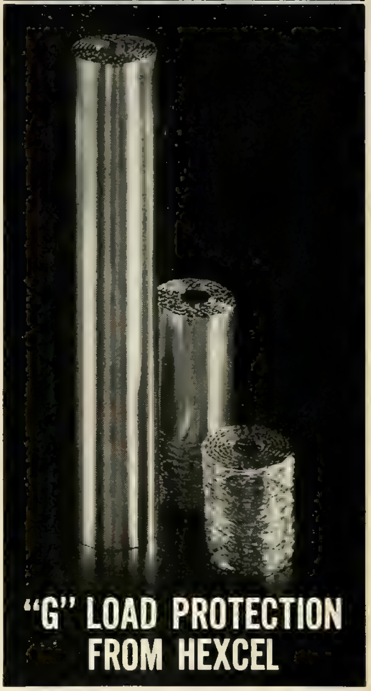
Oxygen is supplied for respiration and suit pressure from a one-pound oxygen tank stored at 1,000 psi, which is rechargeable from the vehicle supply. A canister with lithium hydroxide and activated charcoal for CO_2 removal and trace contaminant control respectively is carried in the backpack. This unit is interchangeable with a canister in the LEM environmental control system.

Gas enters the suit at 6 cfm, at a temperature of about 60°F. It flows to the helmet, where it is respired and picks up CO_2. It then flows over the remainder of the body for pressurization of the suit and to pick up trace body contaminants. The flow then leaves the suit, and passes over the contaminant control canister. It then flows through the water boiler heat exchanger, where it is cooled to 45° to remove sensible heat and moisture is condensed, removing latent heat load. The moisture is removed from the air in a water separator and stored.

Although this gas transport loop serves as a backup heat-removal cycle, main thermal control is accomplished through the liquid transport loop incorporated early last year (M/R, June 22, 1964, p. 28). Water is ducted throughout a thermal undergarment in tubes at a rate of 4 lbs./min., 15 psig, at a temperature of 45°F; it circulates over the body except the hands and feet, and leaves at a temperature of about 53°. It then flows through an accumulator, to a pump and through a water boiler heat exchanger where body heat is exchanged. The boiler in this case is a unique sublimator designed at Hamilton Standard.

Savage says there are no foreseeable problems in the PLSS, and work now is directed toward testing the units for delivery. Hamilton Standard's new vacuum chamber will be used for manned tests, and a "canned man" with metabolic rates simulating man's will be employed. ■





"G" LOAD PROTECTION FROM HEXCEL

- This material gives more efficient energy absorption for high slenderness-ratio tube forms than any material known.
- It is cylindrical aluminum honeycomb.
- It is called TUBE-CORE®.
- It can be designed for crush strengths ranging from 40 to 4,000 p.s.i., to suit most any environment and life expectancy.
- It requires no lubrication and costs far less than hydraulic units.
- TUBE-CORE® is custom-designed to meet exact energy absorption requirements.

For descriptive literature, call or write to:

HEXCEL PRODUCTS INC
World leader in research and manufacture of honeycomb core materials.

Executive Offices: 2332 M Fourth St., Berkeley 10, Calif.

Applications Engineering Offices: Huntsville, Ala., (205) 536-0936; Inglewood, Calif., (213) OR 8-4121; Havre de Grace, Md., (301) WE 9-2900; Arlington, Tex., (817) CR 4-2578

Circle No. 6 on Subscriber Service Card

Vast Expansion in Computer Use Seen

Advances in batch-fabrication processes will reduce costs, make systems similar to public utilities in availability

by Rex Pay

LOS ANGELES—Explosive growth in the use of computers as a result of price reductions at both ends of the size range is forecast because of developments in electronic batch fabrication processes.

First impact will be in the emergence of electronic desk calculators in the $2,000 to $5,000 price range. Four or five firms are reported to be starting to fabricate these machines from low-cost integrated circuits. These should hit the market in one to two years.

By 1970, huge central computers that serve many peripheral users will be developed, at a cost that enables them to function as a public utility in which many small users share the overhead.

Diffused silicon integrated circuits in very large arrays will be the chief batch process making these developments possible. Where necessary, this basic technique will be supplemented with compatible thin-film elements on the semiconductor surface, or they will be combined in groups with thin-film elements on an insulating substrate with deposited interconnections.

- **Breakthrough predicted**—After 1970, computers of new orders of magnitude are likely to appear, fabricated by technology X.

These conclusions were reached at the Institute of Electrical and Electronics Engineers' (IEEE) Computer Group Conference on the impact of batch fabrication on future computers, held here.

Technology X was not identified. Many candidates were put forward, including cryoelectrics, MOS devices, and thin-film active devices. All are promising but none offers a size reduction of several orders of magnitude over current integrated circuits, a solution to the interconnection and access problems imposed by such a size scale, or a form of organization practical for computers of the complexity they would make feasible.

Many people believe an entirely new technology will appear in the next three years to meet these requirements.

Before this new technology becomes practical, however, diffused silicon integrated circuits are likely to go through a revolution in complexity greater than that represented by their development from transistors.

Integrated circuits with 1,000 components are now being studied in manufacturers' laboratories. Texas Instruments has produced an experimental integrated circuit containing 150 gates. General Micro-Electronics is developing metal oxide silicon devices with the equivalent of 300 elements per chip. Motorola Semiconductor is developing a flip-chip package containing a number of integrated circuits flipped on the same insulating substrate, connected by deposited leads.

- **TI progress**—From the tenor of remarks at the conference, Texas Instruments appears to be furthest advanced in the push for complexity within a single diffused-circuit package. Because complex multi-element devices will be required in only small batches, the company's philosophy is to make as much of the process of fabricating a variety of functional blocks as common as possible. The aim is to produce arrays of logic gates on a single slice of silicon, test each device, and then interconnect devices in the slice in a unique fashion to produce the overall function required by a customer.

The function he obtains from the external pins of the device will always meet the customer's specifications. But the internal connections within the unit will vary for functionally identical devices. The only process step that TI has to vary is the final interconnection mask, to provide a range of functions from a range of configurations of usable gates.

The economics of this approach was questioned at the conference. A member of Fairchild Semiconductor said that his company had looked at this type of process and was not convinced it would lead to lower costs.

Interconnection of 150 gates on a single slice of silicon is far from simple. Jack S. Kilby, TI, said that the complexity of interconnections required had led TI to develop a capability to lay down three layers of interconnections on top of the slice (with insulating layers between them), as well as a fourth layer of interconnection obtained by tunneling through the slice.

The economics of the process hang on the development of an automatic technique for designing and forming the interconnections; in particular, in making use of the increasingly low cost of computing.

The 100% testing of devices on a slice is customary, and automatic instruments are used for this. In the process planned at TI, however, the results of the test would be routed to a digital computer that would select an interconnection pattern to provide the desired logic function.

Devices that do not meet nominal specifications may be used in this scheme. For example, a gate that gave a fan-out of three instead of six would be located in a part of the circuit where this degradation of performance is acceptable. As the gate would have been discarded in a process using a rigid interconnection pattern, this is one of the economies of the technique.

To avoid the cost of making new interconnection masks each time a circuit is produced, TI is planning to use a programmable light beam that will move directly over the photo-resist layer on top of the microcircuit slice.

"We do see this as a very low-cost technique," said Kilby. "The added gates we could pick up would more than pay for the computer design needed to make each configuration."

- **Acceptable reliability**—In his view, reliability of these complex circuits would be very similar to that of current integrated circuits. "All the information suggests that the failure mechanism is much more a function of the package than the complexity of the circuit inside," he said. TI is investigating 50-lead packages with dimensions of 0.75 in. by 0.375 in.

There is no problem in dissipating heat from the circuits at moderate propagation delays, said Kilby. They can be operated at higher speeds if they are spread farther apart, and in many applications this is acceptable. Also, the proximity of devices within a single package makes them less susceptible to external noise, and their power level can be decreased without hurting noise margins.

The proximity also reduces the amount of interconnecting circuit impedance and so cuts power requirements further.

• **Complexity breeds disenchantment**—Several speakers at the conference emphasized the fact that as the circuit complexity within a given module increased, so its potential number of applications and market decreased. TI was not the only company reporting use of computer techniques to bring flexibility and fast change of design to the basic batch process.

Computer-controlled batch fabrication of boards for the IBM System/360 computers was described by Alfred H. Johnson, IBM-GPD Manufacturing Research Laboratory. In the System/360, cards carrying various numbers of microelectronic modules are plugged into larger boards. With minor exceptions, all boards are identical and have 6,200 plated-through holes and 2,064 pins. Design of the printed circuit interconnecting wiring on these boards is carried out by an IBM 7090 data-processing system.

Production of the boards is achieved with a printed circuit generator, which converts the digital data from the 7090 into a precisely moving light beam that describes the printed pattern. (The same technique is being pursued by TI at the integrated circuit level.)

Customizing these boards to suit the requirements of a specific user is carried out by a wire-wrap machine operating on the back of the board under control from magnetic tape. The machine senses a code number of the board as it receives it and interrogates a computer controller for instructions about the wiring scheme required.

The final step in the process is examination of the completed board in a testing machine, which also operates from data from the central computer controller.

The computer controller maintains a record of all completed boards and provides quality control information. Inquiries can be made through this unit to determine status of in-process boards.

• **Testing problems**—The difficulties of testing highly complex circuits was emphasized by many speakers. One went so far as to assert that a level of complexity is being reached in which complete testing is impossible. There seemed to be a general opinion that a small general-purpose computer would be essential for testing the functional units now being developed with 30-50 leads per package.

In fact, the whole batch process appears likely to make increasing demands on computers. Computer aids to design, as well as new methods of logical design, were cited as necessary to cope with the increased complexity within a single module.

Of the changes in computer design likely to result from batch fabrication, the most likely one in the near future is the breaking down of the difference between the main units of a computer—arithmetic, control and memory. The trend has already started in the IBM 360/92, to be marketed in 1967. To the user, this appears as a conventional serial machine, but it has a certain amount of distributed memory, arithmetic and control in separate functioning islands.

In non-batch fabricated computers, the arithmetic unit accounts for about 10-15% of the cost. This is the only unit that is suitable for batch fabrication at present. However, linear circuits are being attacked vigorously and are likely to yield to batch fabrication. The present tendency to distribute memory back into smaller units is also making semiconductor batch-fabrication competitive with magnetic core construction.

Memory, control and arithmetic units are likely to be intermingled and built together by a batch-fabrication process in future computers. ■

Parker
METAL V-SEAL
A RELIABLE WEIGHT REDUCING SEAL FOR EXTREME ENVIRONMENTS

Today's engineer must cope with such environments as temperatures ranging from —423°F. to plus 2000°F., from hard vacuum to high pressures, and exposure to extremely volatile and corrosive media or radiation. Parker's Metal V-Seal represents a significant achievement in the search for an effective, economical and weight reducing static face seal to meet these extreme demands . . . Designed, engineered and made to Parker's high standards of quality and dependability.

BASIC ADVANTAGES:
- High resistance to corrosive and volatile chemicals
- Low flange loads to minimize system weights
- High resiliency to compensate for flange deflections
- No special flange machining required (can be made to fit almost any existing groove and some styles do not even need a groove!)
- Reusable several times under most conditions
- Wide variety of seal metals, platings, and coatings to meet specific requirements
- Full range of standard sizes from ¼" to 15" O.D. (Larger on special order)

Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio

Want more information? Send for Catalog 8800

Circle No. 7 on Subscriber Service Card

ROCKET PROPULSION

For the planned expansion of this Division, we require additional members for our professional staff with experience in . . .

ANALYTICAL DESIGN

For thermodynamics and fluid dynamics. Will develop and conduct analytical programs toward solution of design problems in the field of advanced rocket propulsion. BS, ME, ChE or closely related disciplines. Master's Degree preferred. At least three years' intensive experience in heat transfer, thermo, gas, or fluid dynamics.

PROPULSION SPECIALISTS

ME, AE, or ChE with minimum of five years of liquid fuel rocket engine design experience. Strong knowledge of rocket performance characteristics. Will do creative and preliminary design of advanced propulsion systems.

Here's an opportunity to take a positive approach to the problems of space propulsion through our many new programs. You may contact us in confidence by writing to Mr. Holden Rigby, Professional Placement Supervisor, at following address.

Thiokol
CHEMICAL CORPORATION
Reaction Motors Division
Denville, New Jersey 07834

Circle No. 14 on Subscriber Service Card

Radar, ECM Gains Seen With Sperry Delay Line

by Michael Getler

SUDBURY, MASS.—A development of major potential importance to future radar and electronic-contermeasure systems has been reported by scientists at Sperry Rand Corp.'s Research Center here.

They have developed an experimental solid-state microwave delay line which not only provides both fixed and variable delays of incoming X-band signals but produces substantial parametric amplification of those signals. Sperry claims an important "first" in demonstrating amplification of delayed signals at X-band frequencies.

The importance of delay lines to advanced ground-based pulse compression (PC), or "chirp," radars is already well established. However, Sperry scientists say the techniques now available are physically unwieldy and largely inefficient. In general, these techniques demand either literally miles of coiled coaxial cable, to achieve microseconds of signal delay, or bulky solid-state equipments. In either case, the delay function associated with pulse compression is actually performed at an intermediate frequency (IF) level in the system, reduced to a very small fraction of the radar's transmitted microwave frequency. This reduces the effective bandwidth of the radar, thereby reducing its range resolution, and also requires down-conversion frequency equipment.

Both techniques, therefore, suffer from the very high insertion losses associated with use of cable, and/or from severe reductions in useable bandwidth. Because of the high losses, extensive tube-type amplification is also generally required to amplify a portion of the remaining signal. Sperry scientists report that the best available delay lines operating with X-band signals exhibit about an 80-db loss.

They add that they do not believe any PC radars are in use which allow the compression to take place at the microwave frequency rather than at the much lower IF, and that the problems associated with microwave delay lines have in fact largely inhibited development of PC radars in the widely used X-band region.

In PC radars, transmitters put out a broad pulse at high average power rather than a narrower pulse whose peak power might overstress a transmitter. The delay line in the system in effect allows the radar to put out a broad frequency-modulated pulse, with the target return pulse delayed and reconstructed so as to provide the equivalent information that could be obtained with a narrower high power pulse.

Since the amount of range resolution for the radar is actually a function of the useable bandwidth of the delay line, the importance of this component to ground-based radars is apparent.

- **FOR ARIS**—For example, Sperry, which is the prime contractor on the AF Advanced Range Instrumentation Ships (ARIS) program (M/R, June 4, 1962, p. 34), reports that the current ARIS radar provides about a 200-yard range resolution. The high-precision radars aboard the ARIS ships operate at C-band, and use a lump-constant delay element operating on the reduced intermediate frequency.

Developing a delay line with a 10% bandwith (which scientists say is no problem) that can operate at the much higher transmitted microwave frequencies, thereby removing the IF stage, would make it possible to increase the equivalent range resolution of an ARIS-type system to about 5 ft., according to Sperry. This would obviously aid in radar discrimination between incoming warheads and the tankage and other associated intended and unintended debris accompanying re-entry.

In Doppler radars, delay lines are also of major importance, providing a memory of the transmitted reference signal which allows delayed comparison of transmitted frequency with returns shifted in frequency by target motion.

- **For countermeasures**—The use of the new technique in countermeasure systems is perhaps even more intriguing, and Sperry officials say it is in this area that the delay line is apt to find its first company-proposed use.

A countermeasure role would take

advantage of the basic memory capacity inherent in delayed electronic signals. The relatively low insertion losses claimed for the technique would make it useable in some applications where low transmitted signal strengths might not permit use of more conventional delay systems.

Sperry feels that the delay line could be used on a re-entering vehicle or on an airborne or spaceborne target as part of a system whereby energy from an enemy tracking radar is stored in the line long enough to determine what the frequency of the tracking radar is and then initiate jamming action. It believes the system could also be used to mask the signature of target vehicles and to effect spurious returns at a ground station. For example, radar energy collected aboard a target vehicle could be delayed by a receiving system for several microseconds; this could indicate to ground trackers that the target was actually hundreds of miles further out than was suspected and could actually cause a tracking system to loose lock.

The Sperry work was carried out under direction of Dr. Richard W. Damon and his associate, Herman van de Vaart, of the center's solid state sciences group. The work, underway for two years, has received NASA OART support, and Air Force Cambridge Research Laboratories funds for the amplification portion of the development, in addition to in-house funding.

- **High-purity rod**—The Sperry system consists of a 1-cm-long, 0.3-cm-dia. rod of single-crystal yttrium iron garnet (YIG). High-purity YIG rods have very low magnetic loss characteristics.

One end of the rod was inserted into an X-band rectangular waveguide cavity, and the other end into a shorted K_u-band waveguide. The K_u-band was used as the parametric pumping source. The X-band equipment consisted of a pulsed source operating at 8,700 mc and a sensitive receiver connected through a ferrite circulator to the cavity. The K_u-band equipment was a 17,400-mc magnetron, twice the X-band frequency, providing a 1-microsec pulse of up to 500 watts peak power. The RF magnetic fields were parallel at the two ends of the rod, Sperry reports, and were perpendicular to the rod axis. The YIG rod and adjacent waveguides were immersed in liquid helium for most of the experiments, but amplified echoes reportedly were also observed at liquid nitrogen temperatures.

In the initial experiments, an X-band signal at nanowatts of power was put into the YIG rod. The rod, which requires no coupling transducers and in effect acts as its own transducer, Sperry says, converts the X-band input into what Damon calls magnetoelastic waves

10,000 PSIG Y-Globe Valves for high flow requirements

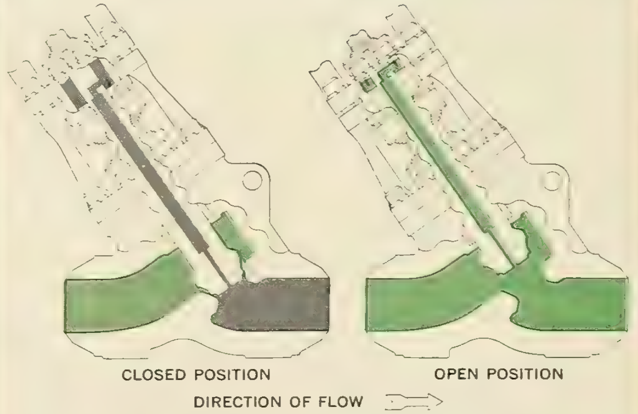
A series of Y-globe valves for 10,000 PSIG working pressure operate with flow coefficients approaching those of gate valves. At 10,000 PSIG operating pressure, less than 35 PSIG cylinder pressure actuates the valves; less than 160 in.-lbs. handwheel torque opens and closes the valves within 12 revolutions maximum.

To assure smooth control in severe high-pressure applications, a compensating pressure disc assembly facilitates fast, cushioned stroking when opening and closing the valve with high differential pressures and velocities across the valve port.

CPD series valves are available in cylinder operated, manual operated and cylinder operated with auxiliary handwheel configurations in sizes from 1½" through 8" for operation over a temperature range of −452°F to +750°F.

Write for 8-page brochure describing operation and specifications.

COMPENSATING PRESSURE DISC OPERATION



Calmec compensating pressure disc assembly overcomes severe high pressure control problems by eliminating undesired line pressure forces acting against the valve stem and against both upstream and downstream sides of the internal valve plug. Equilibrating pressure on the valve plug and piston provides a cushioning effect and assures smooth stroking of the valve.

PATENTS PENDING

CALMEC

CALMEC MANUFACTURING CORP.
5825 District Boulevard • Los Angeles 22, Calif. • (213) 588-6204 • TWX (213) 773-5796

Circle No. 8 on Subscriber Service Card

—a combination of spin waves and sound waves. At the opposite end of the rod, the K_u-band pumping source was applied at about 100 watts for parametric amplification. The time delay between the pump and the reconverted X-band output is a function of the magnetic field applied, with a change of 20 Gauss in the field resulting in a 1-microsec. change in signal delay.

In the initial experiments, Sperry reports that the nanowatt X-band input pulses were delayed between 5-15 micro seconds by the rod and exhibited delayed X-band output pulses amplified to a level 35 db larger than the input pulse. Damon reports that even higher gains were seen in some experiments. He also reported that the device has demonstrated at least a 4-5-mc bandwidth at the peak amplification.

• **Airborne possibilities**—The implications of the Sperry experiment could also be extended to airborne pulse compression radars, but the cryogenic techniques required for X-band operation (primarily to prevent sound wave loss) could prove to be unacceptable. However, scientists here point out that operating at lower frequencies, such as L-band, probably would not require cooling.

The work continuing at Sperry is aimed at exploring some of the new low-frequency potential for the system, in addition to attempting to reduce the system size, which already promises major gains over more conventional methods. Sperry also says it will explore the use of other low-loss magnetic materials for the delay-line role. Some promise is seen for lithium ferrite. Other work will involve more extensive noise measurements at peak gain, but Damon says early analysis indicates that the parametric pumping procedure will keep circuit noise under control.

Improved techniques also will be sought for variable delay operation before the technique is included in Sperry proposals on new ground radars. ■

---

advanced electronics

Douglas Improves Battery Materials

Newport Beach, Calif.—Battery materials that can withstand thermal cycling specified for sterilization of interplanetary spacecraft have been developed by Douglas Missile and Space Systems Div.'s Astropower Laboratory (M/R, Feb. 1, p. 21).

A multi-plate prototype silver-zinc battery of this type is likely to be produced within eight months, said F. R. Arrance, Chief Chemist at Astropower.

Heating processes are used during fabrication of the battery elements so that any changes due to thermal effects take place before sterilization. This forestalls reduction of the silver oxide that has occurred during JPL-sponsored sterilization tests on conventional batteries.

Arrance said that the laboratory had developed electrodes, separators, case materials, and seals that have withstood heat sterilization. "We feel we have the elements for making a completely sealed sterilizable cell," he said.

Present cycle lifetimes with experimental Astropower batteries are extending up to 2,800 cycles, on a half-hour discharge, half-hour charge cycle at 100°C.

In general, tests of cycle lifetime are made at 0°, 25°, 100°, 125°, and 150°C. This enables the high-temperature performance to be compared with the room-temperature performance. For most space applications, a capability of operating at 100°C or below is needed. Only sterilization calls for higher temperatures.

• **Better separators**—The main problem in sterilizing batteries by heat in the past has been the rapid deterioration of the separators. To overcome this, Astropower has produced inorganic separators by modified flame spraying, by compression and sintering, and by molding.

Using inorganic materials for construction not only provides insensitivity to high temperatures but raises cycle life by a factor of 10, said Arrance.

Inorganic battery separators have the advantage of being chemically inert at all test operating temperatures, are geometrically stable, and are not attacked by the silver electrode. They resist puncture by dendritic growth and can be made with controlled porosity.

Separator thickness in the Astropower batteries usually ranges from 0.008 to 0.040 in. Immersion of inorganic separators in a pressure vessel with concentrated potassium hydroxide heated to 150°C had no effect on strength, percentage absorption, or resistivity, Astropower reports.

• **More efficient electrodes**—To raise electrode performance to match the passivity of the separators, inorganic network-supporting materials have been developed. Electrodes using these have shown efficiencies in the range 90-92% of that theoretically achievable. This high figure came as something of a surprise and has resulted in an intensive study of electrodes of this type.

Terminal sealing and case sealing were recognized as major problem areas for high-temperature operation. The approach at Astropower is to assemble the separators and electrodes as a series of integral units that can be molded into a case and sealed at the same time.

• **Silver-zinc gets biggest effort**—Most work has been standardized on a 0.5 A-h cell, which will form the basis for multiple plate cells. Silver-zinc, silver-cadmium, and nickel-cadmium cells are all being studied, but most effort is on silver-zinc systems. These have the highest density of energy storage, but have had poor cycle lifetimes.

Shelf life or wet stand life is a problem in high-density batteries, mainly because of deterioration of the separator. Inorganic separators do not give this problem, however. A battery left on eight months wet stand showed no sign of deterioration and showed excellent charge retention. In cycling tests the performance was essentially the same as that of a fresh battery.

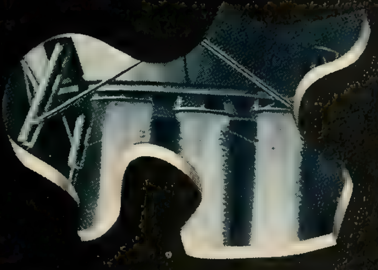
The program of battery development at Astropower is about three years old. Originally the intention was to develop a high-temperature battery, but as the program developed the aim became one of providing a battery with a high-temperature capability.

Arrance sees considerable commercial potential for batteries unaffected by high temperatures. The present growth of cordless appliances is not likely to continue if, for example, a cordless drill left in the sun has its batteries ruined, or a similar thing happens to a shaver left in a glove compartment. At present the critical temperature for storage batteries is about 70°C (158°F).

• **Higher temperatures, higher efficiencies**—There is also an advantage in operating batteries at higher temperatures. It leads to an increase in efficiency in the charge-discharge ratio. This can rise from 70% at 30°C to 97% at 95°C.

For space vehicles, other advantages of high-temperature operation lie in weight savings due to absence of a need for a heat-removal system within the battery, the simplification or removal of external temperature-control systems, and the removal of restrictions on the location of batteries within a spacecraft. ■

Which counts more: the sum or the parts?



A successful space mission requires the focusing of many viewpoints. One man sees the capsule as dead weight to be accelerated. Others view it as a problem in control, stress, thermodynamics, life support. Each view is correct; none is complete in itself.

At United Technology Center, we specialize in propulsion. Solids, liquids, hybrids, ranging from powerful boosters to tiny, variable-thrust motors for landing or docking. Just as important, our capabilities include a deep **identification with the total mission,** not just our part of it.

Put another way, we're team players—from the first word of the contract all the way to the final touchdown.

UTC United Technology Center DIVISION OF UNITED AIRCRAFT CORPORATION UA

ASSOCIATE PRIME CONTRACTOR FOR THE AIR FORCE'S TITAN III PROGRAM.

Circle No. 9 on Subscriber Service Card

GOOD NEWS REPORTS:

MARIETTA, GEORGIA:

"Two 10-channel, type S-II Dynograph® recorders operating continuously since installed, May, 1964. No difficulties."

SCOVILLE, IDAHO:

"Fourteen six-channel Type S-II instruments, used on 24-hour-day basis on tests up to eight weeks, provide most accurate data. No test data lost. No problems."

LOS ANGELES, CALIFORNIA:

"Eighty channels on Type S-II Dynograph recorders operating perfectly. No artifacts evident in six months on high sensitivity product check-out certification tests. Customer delighted."

This reliability and fine performance is typical of the solid-state Beckman Type S-II Dynograph Recorder. Representatives all over the country report the same thing, again and again.

Just as importantly, users find recorded data is the most accurate and best recorded of any direct-writing oscillograph. Servo feedback from every pen tip gives a locked-in trace. Between-channel time comparisons are of the highest accuracy – across 8 channels pen traces are within .010″ of a straight line. Type S-II specs assure sensitivity of 1mv/div to 5v/div; differential and floating input; system accuracy to 0.25%; and linearity of ±0.25% full scale. The zero weave paper and the pressurized ink supply assure fine readability and no paper drift at all speeds.

Over 30 input couplers allow the conditioning of virtually any input signal, so you can adapt the Dynograph Recorder to your changing requirements at very little cost.

This combination of reliability, accuracy and flexibility comes only with a Beckman Dynograph Recorder. For more information contact your local Offner Division Sales Engineering Representative, or write for Data File 722.

Beckman® INSTRUMENTS, INC.
OFFNER DIVISION
SCHILLER PARK, ILLINOIS • 60176

INTERNATIONAL SUBSIDIARIES: GENEVA, SWITZERLAND; MUNICH, GERMANY; GLENROTHES, SCOTLAND; PARIS, FRANCE; TOKYO, JAPAN; CAPETOWN, SOUTH AFRICA

Circle No. 10 on Subscriber Service Card

The Industry Week

Mergers and Acquisitions

Teledyne, Inc.'s Ordnance Specialties, Inc., division has been combined with McCormick Selph, the ordnance systems division of Teledyne. All OSI inventory, work-in-progress, equipment and key personnel have been relocated to McCormick Selph facilities in Hollister, Calif. The OSI product line includes reefing line cutters, solid propellant igniters, safe-arm mechanisms, 20- and 40-mm fuze components, electric primers and new ordnance specialties . . . *Computer Sciences Corp., El Segundo, Calif., has agreed to buy Potter Aeronautical Corp. of Union, N.J. Potter designs and develops precision engineered flow measurement devices and related electronic instrumentation for the aerospace, brewing and petrochemical industries. PA will operate as a subsidy of CSC.* . . . Laboratory for Electronics, Inc., Waltham, Mass., has acquired the magnetostrictive delay line business of Ferranti Electric, Inc., Plainview, N.Y. Included in the acquisition is Ferranti's title to the basic patent for torsional magnetostrictive delay lines. Ferranti is a subsidiary of Ferranti, Ltd., of Lancashire, England . . . *The boards of directors of Electronic Specialty Co. and International Heater Co. have agreed to the purchase of IH by ES for an undisclosed amount of cash. If approved by IH shareholders, the firm will operate as a division of ES.* . . . Andersen Laboratories, Inc., West Hartford, Conn., has purchased the delay line business of Richard D. Brew and Co., Inc., Concord, N.H. Aim of the purchase is to provide AL with additional advanced technology in dispersive and non-dispersive strip lines, solid delay lines and lumped constant lines.

Firms Join Improvement Drive

Grumman Aircraft and Honeywell, Inc., are the most recent entries in the Martin Co.-instituted and DOD-adopted "Zero-Defects" product improvement program with Projects "Sterling" and "STEP," respectively. Grumman is putting new emphasis on its employee suggestion program and achievement awards. Honeywell's military plants have assigned full-time STEP program managers and are stressing the continuing nature of the campaign.

Facility Expansions

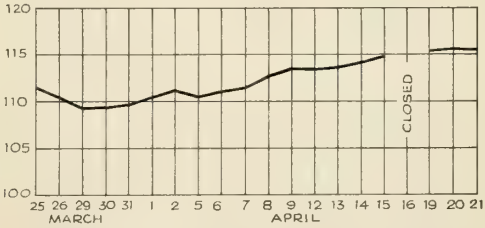
Space Ornance Systems, Inc., has leased a 6,000-sq.-ft. plant adjacent to its present facilities in El Segundo, Calif. The new building will be used for production of ordnance devices and systems for Project *Apollo*, and other space and aircraft programs in which SOS is engaged. The facility will house an environmentally controlled white room for use in assembling ballistic-actuated devices, an enlarged machine shop, and offices for resident customer staffs. . . . *Melpar, Inc., has established a Solar Energy Applications Laboratory at its Falls Church, Va., facility. The new lab will be used in scientific investigations in such areas as solar powered thermoelectric devices, solar powered water distillation systems and survivable technology.* . . . Sperry Rand Corp. has begun construction of a 25,000-sq.-ft. building in Huntsville, Ala., to house personnel of its Space Support Div. The division has been selected by NASA to provide support services for the Marshall Space Flight Center's Astrionics Laboratory. Occupancy by 250 employees is planned in May.

New Activities

The Martin Co.'s Denver Div. and the Denver Research Institute has formed a joint organization to investigate new types of metal forming. The new organization, to be called the Center for High-Energy-Rate Forming Processes, will use facilities and technical personnel at both Martin and DRI. The new organization has already received a $1-million contract for the Advanced Research Projects Agency of the Defense Dept. Explosive forming will be the primary interest of the center. . . . *Montronics, Inc., a wholly owned subsidiary of the John Fluke Mfg. Co. of Seattle, is being moved from Bozeman, Mont., to Seattle. Montronics builds frequency synthesizers, comparitors and distribution amplifiers.* . . . James Electronics, Inc., Chicago, has formed a new Instrument Div. to develop, manufacture and sell electronic test instuments, concentrating on the use of ultrasonic techniques for industrial and bio-medical applications. First product to be marketed by the new division is Ultra-Scan, an ultrasound image conversion system for non-destructive examination of metals and organic tissue.

Missile/Space Stock Index

The Missile/Space stock index broke all previous records by climbing over 115 on April 19 and remaining there through the 21st. The rise represents a 15% increase since the first of the year in the 19 aerospace stocks selected as representative of the aerospace market. Again this week, large increases were noted in companies involved in the F-111 contract, after the plane was ordered into production by Defense Secretary McNamara. The upsurge was further influenced by the war in Viet Nam.



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

contracts and procurements

AWARDS

AIR FORCE

$3,277,197—**General Telephone and Electronics Corp.,** Sylvania Electric Products, Inc., New York City, for spare parts for electronic data processing equipment.

$3,000,000—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for engineering support for *Agena* boosters.

$1,300,000—**North American Aviation, Inc.,** Columbus Div., Columbus, Ohio, for continued work on an advanced air-to-surface missile.

$1,205,000—**The Boeing Co.,** Seattle, for continued work on *Minuteman* missiles.

$875,000—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for exploratory development on contact ionization thrustor.

$751,414—**Martin Co.,** Denver Div., Denver, Colo., for conceptual study for a large payload test vehicle.

$700,000—**McDonnell Aircraft Corp.,** St. Louis, for the *ASSET* program.

$150,000—**Olin Mathieson Chemical Corp.,** Chemical Div., New Haven, Conn., for high-energy propellant ingredient research.

$150,000—**Engelhard Industries, Inc.,** Attleboro, Mass., for manufacturing methods for form rolling complex shapes of high-strength titanium alloys.

$141,573—**United Aircraft Corp.,** Pratt and Whitney Aircraft Div., West Palm Beach, Fla., supplemental contract for exploratory development program directed toward high-energy advanced throttling concept.

$109,065—**North American Aviation, Inc.,** Rocketdyne Div., Canoga Park, Calif., for engineering property data on rocket propellants.

$100,000—**Hughes Aircraft Co.,** Culver City, Calif., for research of laser devices exploratory investigation.

$79,500—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for investigation of thermodynamic properties of rocket combustion products.

$76,382—**United Aircraft Corp.,** Hamilton Standard Div., Windsor Locks, Conn., for research on exhaust gas effects on heat exchangers.

$58,000—**General Telephone and Electronics Corp.,** Sylvania Electric Products, Inc., West Roxbury, Mass., for training of Strategic Air Command officers scheduled to form *Minuteman* ICBM troubleshooting teams.

$41,990—**E. I. DuPont deNemours and Co.,** Wilmington, Del., for research on the friction of wear of nonmetallic solids.

$26,445—**Atlantic Research Corp.,** Alexandria, Va., for development, preparation and delivery of an uncured solid propellant having a flame temperature of 6,500°F.

ARMY

$1,450,000—**International Telephone and Telegraph Corp.,** Kellogg Communications Systems Div., Chicago, to supply electronic switchboards.

$660,000—**International Telephone and Telegraph Corp.,** Federal Laboratories Div., Nutley, N.J., for components of the integrate guidance and control system for the MQM-58A system.

$478,276—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., for AN/PRC-25 product improvement program.

$357,750—**Lockheed Propulsion Co.,** Redlands, Calif., for *Javelin III* and *Hydrac* rocket motors.

Kellett Aircraft Corp., Willow Grove, Pa., for the manufacture of aircraft fuel tank and pylon assemblies (amount not disclosed).

NAVY

$10,980,061—**Aerojet-General Corp.,** Azusa, Calif., for continued production of Mark 46 torpedoes.

$5,326,300—**American Telephone and Telegraph Co.,** Western Electric Co., Whippany, N.J., for work on an oceanographic research program.

$2,192,845—**General Dynamics Corp.,** Pomona, Calif., for production of *Tartar* and *Terrier* missiles.

$1,886,246—**Technical Materiel Corp.,** Mamaroneck, N.Y., for spare parts for various communications systems.

$1,450,000—**The Bendix Corp.,** Mishawaka, Ind., for development and testing of the *Talos* air defense missile.

$822,592—**Ling-Temco-Vought, Inc.,** LTV Range Systems Div., Dallas, for *Jindivik,* Mark 3A target flight equipment.

$675,000—**North American Aviation, Inc.,** Columbus Div., Columbus, Ohio, to perform preliminary work on a short-range missile that would be guided by television (*Condor*).

$675,000—**Northrop Corp.,** Nortronics Div., Hawthorne, Calif., to perform preliminary work on a short-range missile that would be guided by television (*Condor*).

$648,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., contract increase for a classified program.

$330,600—**Ling-Temco-Vought, Inc.,** Systems Div., Dallas, for technical services and material necessary to conduct aerial flights of the *Jindivik* target drones at Naval Missile Center.

$279,597—**Baldwin Electronics, Inc.,** Little Rock, Ark., for *Sidewinder* influence fuze.

$274,912—**General Dynamics Corp.,** Pomona Div., Pomona, Calif., for replacement parts used on the *Tartar* missile.

$235,000—**Tung-Sol Electric Inc.,** New York City, for power supply units, various services and spare parts.

$198,978—**Space-General Corp.**, El Monte, Calif., for research and development program directed toward determining the feasibility of using a microwave radiometer for missile guidance.

$164,637—**Walter Darwin Teague Associates**, New York City, for engineering services for *Terrier*, *Tartar* and *Talos* missiles and associated equipment.

$131,370—**General Time Corp.**, Westclox Div., Peru, Ill., for safety and arming device Mk 3 Mod 3, *Sidewinder 1A*.

$125,000—**Westinghouse Electric Corp.**, Landsdown, Md., for development of the Mark 48 torpedo.

$90,000—**The Boeing Co.**, Seattle, for follow-on studies of a proposed new Advanced Surface Missile System.

$76,702—**Carborundum Co.**, Niagara Falls, N.Y., contract extension for research and development of advanced ceramic systems for rocket nozzle applications.

$52,000—**Sperry Rand Corp.**, Sperry Gyroscope Co., Great Neck, N.Y., for special study of the Advanced Surface Missile System.

NASA

$1,707,830—**Lockheed Missiles and Space Co.**, Sunnyvale, Calif., for lunar orbiter spacecraft adapter and separation system, fabrication and testing.

$957,500—**Radio Corp. of America**, Astro-Electronics Div., Hightstown, N.J., increase in contract for *Nimbus* APT program.

$642,000—**Honeywell, Inc.**, Aeronautical Div., Minneapolis, for design, fabrication and installation of vehicle motion simulator.

$550,000—**Avondale Shipyards Inc.**, Harvey, La., for conversion of three barges to space vehicle transportation vessels.

$440,000—**Ling-Temco-Vought, Inc.**, Aerospace Div., Dallas, for *Scout* vehicle launcher.

$315,552—**Allied Research Associates**, Concord, Mass., for *Tiros* attitude determination and gridding program.

$149,000—**University of California**, La Jolla, Calif., for experiment to measure trapped protons.

$59,343—**Northrop Corp.**, Northrop Space Laboratories, Hawthorne, Calif., for development of technological concepts leading to beneficial use of lunar magma products.

$39,050—**Lockheed Missiles and Space Co.**, Sunnyvale, Calif., for study of the total radiance of air and radiant energy.

$37,729—**Control Data Corp.**, Minneapolis, for study of a minimum complexity digital computer for automatic lunar surface navigation.

International Telephone and Telegraph Corp., Federal Laboratories Div., Nutley, N.J., to build an infrared telescope to detect spaceborne targets for Langley Research Center (amount not disclosed).

INDUSTRY

$180,000—**Quantic Industries, Inc.**, Pelmec Div., San Carlos, Calif., from **Avco Corp.**, Lycoming Div., Stratford, Conn., for continuing production of the *Minuteman* missile re-entry vehicle separation system.

Electro-Mechanical Research, Inc., Sarasota, Fla., from **Thompson Ramo Wooldridge Corp., Space Technology Laboratories**, Redondo Beach, Calif., to provide FM subcarrier discriminators for *Apollo* tracking network (amount not disclosed).

DEPARTMENT OF DEFENSE

$2,380,000—**Sun Shipbuilding Co.**, Chester, Pa., for fabrication of an atomic blast simulator in Dahlgren, Va.

$1,250,000—**Geotechnical Corp.**, Dallas for continued operation of two seismic-detection observatories and new operation of a third station near Payson, Ariz.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama

MSFC will negotiate with Northrop Space Laboratories for studies in simultaneous solutions of sets of non-linear algebraic equations related to filter circuit analysis. For information only; RFP not available.

Purchasing Office
George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Huntsville, Alabama

MSFC will negotiate with Lockheed Missiles and Space Co. for experimental and analytical research to obtain gust criteria applicable to control system design of *Saturn*-type vehicles. For information only; RFP not available.

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California 94035

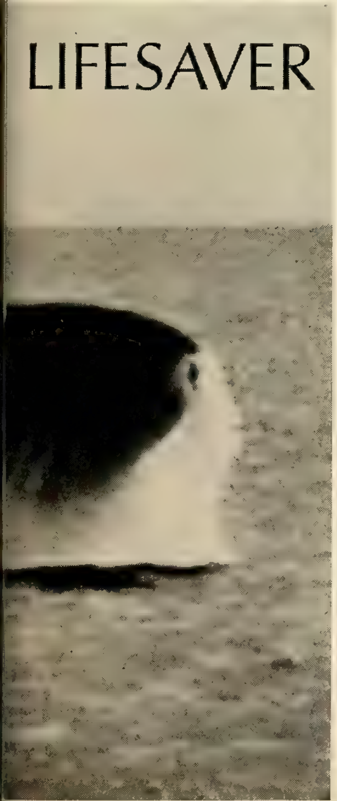
RFP A-10204 (FG-22) due May 3, 1965, for furnishing services, materials and facilities to perform various task orders under a master ageement contract for design, development and manufacture of certain electronic systems and sub-systems for research projects.

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California 94035

RFP A-10205 (FG-21) due May 4, 1965, for furnishing services, materials and facilities to perform various task orders under a master agreement contract for construction and modification of various instruments and mechanisms for research projects.

National Aeronautics and Space Administration
Manned Spacecraft Center
General Research Procurement Branch
2101 Webster-Seabrook Road
Houston, Texas 77058

RFP BG721-2A-5-735P due May 17, 1965, for study and development program for a C and X band communications transponder and test set.



LIFESAVER ...for deep-sea submarines

Lockheed Propulsion Company—developer of space lifesaving systems for America's Mercury and Apollo astronauts—is now developing a revolutionary safety system for deep-diving submarines.

Under assignment of U.S. Navy Bureau of Ships, LPC is developing an emergency ballast expulsion system to greatly improve submarine and crew safety. Highly efficient solid propellant gas generators, located in each ballast tank, will expel tons of sea water—to provide the positive buoyancy required to bring the submarine to the surface.

LPC's ballast expulsion system provides positive, constant buoyancy control and repeatable elements of buoyancy through command selection of tanks to be blown. If a severe incident occurs, all tanks can be blown instantaneously, allowing the submarine to surface rapidly. For crew safety, combustion gases generated by the propellant are non-flammable.

Since LPC's expulsion system provides an advanced method of controlling power, rise time, and buoyancy, it offers a new capability to other Navy operations, including surface and underwater salvage.

PROPULSION ENGINEERS: Excellent career opportunities are now available for qualified engineers, extending from junior into management level positions in: Preliminary design, advanced design, analytical engineering and engineering research. We invite you to write: Professional Employment Manager, Department 5203, P.O. Box 111, Redlands, California. An equal opportunity employer.

LOCKHEED PROPULSION COMPANY

REDLANDS, CALIF. • A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

RELIABILITY
ENGINEERING
OF
Deep-Diving
"S & R" Craft

The U. S. Navy Marine Engineering Laboratory on the waterfront at Annapolis conducts RDT&E in shipboard and submarine machinery and auxiliary systems (electrical, propulsion, control, etc.). The overall objective is to develop basic improvements in performance and reliability . . . i.e., ship silencing, new means of energy conversion, ways to minimize friction and wear, special operating machinery for unusual environments, tough new alloys, etc.

Now, the laboratory is undertaking a very important and difficult assignment—helping to develop deep submergence search and rescue vehicles . . . crafts able to operate under extreme pressure and unfavorable conditions.

Several full-capability Reliability Engineers—people with degree, solid experience, and strong math/statistics background—are needed to conduct studies in reliability apportionment and trade-off, failure mode and fail safe analysis, and systems analyses to optimize mission availability.

Closely related openings also exist in reliability analysis and failure effects of mechanical and electronic systems. In both cases, knowledge of reliability techniques pertaining to ship or submarine machinery would certainly be helpful.

Starting salaries run from $10,250 to $12,075, with regular increases in salary, and full Civil Service benefits. Excellent growth potential since the field of deep submergence operations is just getting underway. Write to Mr. W. M. Siesko, Head—Employment Branch (Code 162-MR).

U. S. NAVY
MARINE ENGINEERING
LABORATORY
Annapolis, Maryland 21402
An Equal Opportunity Employer

products and processes

New Product of the Week: Adhesive/Sealant

An adhesive/sealant, designed for increased tear strength, adhesive strength and tensile strength for missile/space applications, has been announced by Dow Corning Corp.

The Type 92-018 silicone sealant exhibits typical tensile strengths of 700 psi; typical elongations of 750%; peel bond strengths of 75 lbs./in.; and tear strengths of 110 lbs./in. The material is serviceable from −85° to 500°F, adheres to most surfaces, and resists weathering, moisture and ozone, developers say. Specific gravity is 1.07.

The silicone sealant cures on reaction with moisture vapor from the air. It forms a tack-free surface in less than one hour and develops optimum physical properties in five days.

Circle No. 151 on Subscriber Service Card

Frequency Extender

A frequency extender which tunes from 1 to 2 gc in a single band has been introduced by Communication Electronics, Inc.

The Type FE-1-2 employs a 4-section YIG preselector which is tuned electronically throughout its range to avoid complex mechanical drives. Signals are converted to 160-mc IF output and fed into a receiver which tunes to 160 mc.

Image rejection is 70 db minimum; average power consumption is 25 watts. The unit operates from a 115-230-v power source, 50-400 cps, and weighs approximately 20 lbs.

Circle No. 152 on Subscriber Service Card

Digital Frequency Meter

A digital meter that measures audio and supersonic frequencies from 2 cps to 300 kc has been developed by RACAL Communications, Inc.

The Model SA-520 is designed to permit direct measurement of higher frequencies while those at the lower end of the range can be accurately determined through multiple period measurement. Accuracy is ±1 count ±internal crystal stability. The portable unit weighs 7 lbs. and can be operated from a-c sources or batteries. Signal frequency is shown in a 4-digit display. Standard models offer a staggered digital readout.

Circle No. 153 on Subscriber Service Card

DC Torque Motor

A limited rotation type torque motor, featuring improved viscous damping (0.36 oz.in./rad./sec.) with less friction, has been developed by Victor Comptometer Corp.

The unit offers friction plus hysteresis of less than 1 oz.in. Angular motion is ±32 degrees with a total of 64 degress rotation. Standard resistance is 220 ohms, center tapped. Power input of 8 watts dc for 40 oz.in. continuous torque.

Circle No. 154 on Subscriber Service Card

NASA'S NEW ELECTRONICS RESEARCH CENTER

A SPECIAL REPORT...

...to be published in MISSILES AND ROCKETS May 31, 1965 issue. The new center, although just entering the construction phase, has already issued RFP's to industry for electronics research contracts. The center which will eventually direct 50% of NASA's electronics research, has a FY '66 budget which already has reached $22 million, and by 1969 should reach $100 million.

More important, the Electronics Research Center will be in the forefront of NASA's drive to achieve the state-of-the-art advances in electronic systems and components required to carry out the sophisticated space missions planned in the late sixties and through the next two decades.

This report will provide in-depth analyses of Electronics Research Center's plans and programs, procurement policies, responsibility in electronic research and the construction schedule, costs and equipment for the individual laboratories.

For companies marketing to NASA, this report offers a unique opportunity to reach the heart of the buying influences. Plan now to capitalize on this outstanding advertising opportunity.

Bonus Circulation: This issue of MISSILES AND ROCKETS will be delivered to every engineer, every designer, every scientist, and every management man at the Electronics Research Center. Copies will be made available to other Electronic Centers of NASA.

PUBLISHED: MAY 31 **ADVERTISING CLOSES: MAY 17**

missiles and rockets

the weekly of advanced technology

WHO SAYS BUSINESS IS BAD?

MILITARY PUBLICATIONS

	1st 3 Mos. 1965	1st 3 Mos. 1964	Percent Change
ARMED FORCES MANAGEMENT*	138	73	+89.0%
Army	85	61	+39.3
Data	44	34	+29.4
Ordnance	59	53	+11.3
Journal	96	89	+ 7.9
Signal	71	66	+ 7.6
USNIP	76	73	+ 4.1
Air Force	98	111	−13.7
	667	560	+19.1%

AEROSPACE PUBLICATIONS

	1st 3 Mos. 1965	1st 3 Mos. 1964	Percent Change
MISSILES AND ROCKETS*	272	283	− 3.9%
Aviation Week & Space Technology	714	779	− 8.3
Space Aeronautics	220	333	−33.9
	1206	1395	−13.5%

AVIATION PUBLICATIONS

	1st 3 Mos. 1965	1st 3 Mos. 1964	Percent Change
AMERICAN AVIATION*	125	102	+22.5%
Flying	164	140	+17.1
B/CA	138	125	+10.4
AOPA	152	151	+ .7
Flight	114	118	− 3.4
	693	636	+ 9.0%

*American Aviation Publications UP 16.8%

This is what happens when a Publishing House employs 39 of the world's finest business paper editors.

"Specialized Media for Specialized Markets"

AMERICAN AVIATION PUBLICATIONS, INC.
1001 Vermont Avenue, N.W., Washington, D.C.

Page count by Market Research Department, American Aviation Publications

—names in the news—

Robert E. Davis: Named manager of the *Poseidon* program at Aerojet-General Corp. **William J. Keck** will manage first-stage engineering work and **David R. Collis** will manage second-stage engineering activities. Team was named in expectation of subcontract to be awarded by Lockheed Missiles and Space Co. to cover the missile's project definition phase.

Samuel C. Johnson: Elected a director of Cutler-Hammer, Inc. He is executive vice president of S. C. Johnson & Son, Inc.

Jack R. Harned: Appointed manager of public relations for AC Spark Plug Div. of General Motors in their Milwaukee operations.

Estelle S. Ratuzny: Promoted to contracts administrator for defense contracts of Roanwell Corp.

Roy M. Casper: Appointed director of Allis-Chalmers' Research Div. He is also a vice president of the company.

Dr. Hans-Georg Clamann and Dr. Billy E. Welch: Received the Arnold Air Society's Gen. Hoyt S. Vandenberg Award for their outstanding contributions to aerospace development in the field of science during 1964.

Dr. A. I. Mlavsky: Elected executive vice president of Tyco Laboratories and a director of the corporation. **Dr. Georg Rupprecht** was also elected a vice president, responsible for research in solid-state physics, and **Dr. A. C. Makrides** was elected a vice president for research in chemistry and biology.

Allen Wood: Joined Rocket Research Corp. as senior research engineer. He was previously a member of the staff at Jet Propulsion Laboratory.

Preston T. Smith: Appointed director of finance for the Boeing Co.'s Aero-Space Div.

Chris J. Witting: Elected president and a director of the Crouse-Hinds Co. He succeeds **J. R. Tuttle,** chairman of the board, who filled the vacancy caused by the death of **Robert J. Sloan.**

Nathan E. Promisel: Appointed a national trustee of the American Society for Metals. He is chief materials engineer at the Navy's Bureau of Weapons.

Robert A. Burgin: Appointed vice president and director of Thompson Ramo Wooldridge's Space Technology Laboratories, in charge of administrative operations. Also appointed was **Harold Hirsch** as vice president and director of fabrication, integration and test.

Louis R. Lazo: Appointed vice president and general manager of Transport Dynamics, Inc., subsidiary of American Metal Products Co. The division is producer of self-lubricating bearings for jet aircraft, missiles and ground support equipment.

let us move with you!

Six Weeks Is Required To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, if possible, the address label from your last issue . . . include your postal ZIP number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
A. C. Boughton, National Sales Manager
Kenneth C. Blanchard, Director of Research and Marketing

New York, N.Y. 10017—20 East 46 Street; (212)986-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson

Beverly Hills, Calif. 90210—9301 Wilshire Blvd.; (213)272-9827 or 274-8791
Edwin J. Denker, Jr., Western Advertising Manager
Ronald L. Rose

New England: 15 Half Mile Common, Westport, Conn. 06880; (203)227-6867
Gerry Mullin

Boston, Mass. 02116—755 Boylston Street, Suite 306; (617)266-4455
Gerry Mullin

Detroit, Mich. 48237—21990 Greenfield Road, Oak Park, Mich.; (313)547-8880
Michael Rouff

Chicago, Ill. 60601—1 East Wacker Drive, Room 1522; (312)321-1444
Charles E. Durham, Jr.

Miami, Fla. 33022—P.O. Box 890, Hollywood, Fla.; (305)947-6072
R. P. Caldiero

London, W.1., England—44 Conduit Street; REgent 4714
American Magazine Group

Paris, France—11 Rue Condorcet; TRU 15-39

—when and where—

APRIL

Second Annual USA/European Conference, meeting follows this route: Marriott Motor Hotel, Philadelphia, April 25-28; Cape Kennedy, Fla., April 29; and Goddard Space Flight Center, Washington, D.C., April 30.

Western States Spring Meeting of the Combustion Institute, Los Angeles, April 26-27.

Third Annual Seminar-in-Depth, sponsored by the SPIE and U.S. Naval Ordnance Test Station, Los Angeles International Hotel, Los Angeles, April 26-27.

Fourth Symposium on Advanced Propulsion Concepts, sponsored by Air Force Office of Scientific Research and United Aircraft Corp., Cabana Motor Hotel, Palo Alto, Calif., April 26-28.

36th Annual Scientific Meeting, sponsored by the Aerospace Medical Assn., New York Hilton Hotel, New York City, April 26-29.

Pricing and Negotiating Prime and Sub-Contracts in the Defense and Aerospace Industries, sponsored by the Contract Management Institute, Sheraton West, Los Angeles, April 26-30.

National Space Navigation and Spacecraft Communication Meeting, sponsored by the Institute of Navigation, Rice Hotel, Houston, April 29-30.

MAY

67th Annual Meeting of the American Ceramic Society, Bellevue Stratford Hotel, Philadelphia, May 1-6.

Symposium on Numerical Solution of Partial Differential Equations, sponsored by Air Force Office of Scientific Research, Office of Naval Research and University of Maryland, University of Maryland, College Park, Md., May 3-7.

Post-Apollo Missions, sponsored by the American Astronautical Society, Conrad Hilton Hotel, Chicago, May 4-6.

19th Annual Technical Conference of the American Society for Quality Control, Biltmore Hotel, Los Angeles, May 3-5.

Seminar on Systems and Subsystems Management, sponsored by the National Defense Education Institute, New York City, May 4-6.

1965 Microwave Theory and Techniques Symposium, sponsored by Institute of Electrical and Electronics Engineers, Jack Tar Harrison Hotel, Clearwater, Fla., May 5-7.

Spring Meeting of the Society for Experimental Stress Analysis, Cosmopolitan Hotel, Denver, May 5-7.

1965 Electronic Components Conference, sponsored by IEEE and the Electronic Industries Assn., Marriott Twin Bridges Motor Hotel, Washington, D.C., May 5-7.

Sixth National Sympoisum on Human Factors in Electronics, sponsored by IEEE, Sheraton Hotel, Boston, May 6-8.

Advertisers' Index

AVCO RESEARCH & ADVANCED DEVELOPEMENT, DIV. OF AVCO CORP. Agency—Benton & Bowles, Inc.	48
BECKMAN INSTRUMENTS, INC., OFFNER DIV. Agency—Erwin Wasey, Inc	38
CALMEC MFG. CORP. Agency—Schaeper Industrial Adv.	35
CONNECTICUT HARD RUBBER CO. Agency—Charles Palm & Co., Inc.	4
CRYOVAC, INC. Agency—The Jay H. Maish Co.	10
DOUGLAS AIRCRAFT CO., INC., MISSILE & SPACE SYSTEMS DIV. Agency—J. Walter Thompson Co.	5
FAIRCHILD SEMICONDUCTOR Agency—Johnson & Lewis, Inc.	2
GENERAL ELECTRIC CO., MISSISSIPPI TEST SUPPORT OPERATION Agency—Deutsch & Shea, Inc.	18
HEXCEL PRODUCTS, INC. Agency—Lennen & Newell	31
HUGHES AIRCRAFT CO. Agency—Foote, Cone & Belding	47
INTERNATIONAL TELEPHONE & TELEGRAPH CORP. Agency—Needham, Louis & Brorby, Inc.	27
LOCKHEED PROPULSION CO., DIV. OF LOCKHEED AIRCRAFT CORP. Agency—Hal Stebbins, Inc.	40, 41
MARQUARDT CORP. THE Agency—Grant Adv., Inc.	24, 25
PARKER SEAL CO. Agency—The Lester Co.	33
REEVES SOUNDCRAFT CORP. Agency—The Wexton Co., Inc.	11
THIOKOL CHEMICAL CORP., REACTION MOTORS DIV. Agency—MacManus, John & Adams, Inc.	34
UNITED AIRCRAFT CORP., VECTOR DEPT. OF NORDEN DIV. Agency—Cunningham & Walsh Inc.	8
UNITED STATES NAVY, MARINE ENGINEERING LABORATORY Agency—GLM Associates, Inc.	42
UNITED TECHNOLOGY CENTER Agency—Hoefer, Dieterich & Brown, Inc.	37
VITRO CORPORATION OF AMERICA Agency—Buchen Adv., Inc.	6

Freedom of Information

BILLS CONCERNED with freedom of information now are under consideration in the Senate and House of Representatives. They deserve the full support of this industry, which more than any other often finds itself the victim of restrictive government information practices.

Intent of the bills is to establish a Federal public records law and to permit court enforcement of the people's right to know the facts of government. Providing for sensible exceptions in the case of sensitive and classified information, the proposed law would require every agency of the government to make all its records promptly available to any person.

This is of vital importance today because, as the Freedom of Information Committee of the American Society of Newspaper Editors pointed out this month, the past year has not been an encouraging one for freedom of information.

The onus for restrictive news management usually falls on the Dept. of Defense, and rightly so, but there are a number of individuals in the National Aeronautics and Space Administration who are inclined to regard the agency as a preserve which should be off limits to the press. It is to the credit of Administrator James E. Webb that he has a consistent record of correcting abuses of press freedom that are called to his attention. The same cannot be said of his counterpart in the Defense Department.

In fairness, it must be said that DOD has the more difficult task in this area, since legitimate military security requires that much of its activity be classified. It should also be acknowledged that Assistant Secretary of Defense for Public Affairs Arthur Sylvester frequently takes the blame for policies which are not of his making. We have found him always courteous and helpful. It cannot be said, however, that he is a fountain of frank and useful information. The flow might better be likened to a puddle of puff.

The record of the Administration and the Dept. of Defense during the Bay of Pigs affair and the Cuban missile crisis still stands as one of the blackest moments in the history of government-press relations.

Mr. Sylvester has declined to retreat from his declared position at that time that a nation has a right to lie in time of crisis—a stand that has cast a shadow of doubt over all proclamations which since have issued from the Defense Dept.

The ASNE report criticized the public information policy of DOD in the harshest possible terms as one intended to trumpet its praises and cover up its mistakes.

We believe that all too often government information officers confuse their function with that of public relations officials in private industry. An industrial public relations man's primary duty is to his company. He has an obligation to show the company in the best possible light and to soften those blunders that come to public attention. If the company so desires, he can quite rightfully refuse to tell the press about its activities. The most immediate example of this which comes to mind is the no-information policy which prevailed at Hughes Aircraft a decade ago, a situation long since changed.

But the position of the government public information officer is a far different one. He is on the public payroll. He has a duty to the public and to the press, as the representative of that public. His obligation is to provide access to all possible information about his agency. He has no duty to serve as an advocate of his organization. He has no duty to cover up its mistakes. His organization is not a private concern. It has no inherent right to withhold information at its whim. He is a public servant—and should act accordingly.

Unfortunately, this fine distinction between government and industrial public relations all too often escapes those on NASA and DOD payrolls.

On at least one occasion, NASA scientists attempted to hold a meeting which was to be closed to the press, but attended by scientists from Iron Curtain countries. Only after a strong protest from this magazine was the policy reversed—with some bitter in-fighting at the agency which had to be resolved at the highest level. It should be said that in many cases, it is the NASA scientists and DOD executives, not the public information officers, who attempt to impose these restrictions. Frequently, information officers have had to battle internally on behalf of press freedom—an unpleasant and frequently, unrecognized chore for which the press indeed owes a debt of gratitude.

THE FREEDOM OF INFORMATION BILLS introduced by Sen. Edward V. Long (D-Mo.) and Rep. John E. Moss (D-Calif.) would do much to establish the right of the public and press to such government information.

Congressman Moss notes that 10 years of study by his Freedom of Information subcommittee have shown a consistent record of abuse by Federal agencies in using their powers to withhold information.

"These (powers) should be replaced by a clear delineation of sensitive government information which must be held confidential and by an enforceable right of public access to the rest of the facts of government," he says.

Every company in this industry which deals with classified information would be benefited by such a clear-cut policy.

As Rep. William G. Bray (R-Ind.) told the House last week, "The more I have observed the Washington scene, the more convinced I have become that it takes constant watching to keep the Government from becoming extremely secretive about its operations. As our Government grows to mammoth proportions, we have to watch at every level at every moment."

The efforts of Sen. Long and Mr. Moss and the support of the 25 other members of Congress who signed the House and Senate bills are most welcome to the press and the industry. The bills should be passed.

William J. Coughlin

System engineering for airborne weapon systems

FIRE CONTROL SYSTEM FUNCTIONAL DESIGN

Responsibilities: The determination of detailed functional design requirements for complex Airborne Weapon Control Systems; system design per customer requirements; theoretical analysis of system performance and liaison assistance to engineering departments to develop equipment to fulfill system requirements.

Experience in one or more of these areas: **1.** System engineering involving missile or fire control systems. **2.** Field engineering on airborne systems. **3.** Test evaluation. **4.** Pulse doppler and other radar systems. **5.** Digital computer —airborne system. **6.** Inertial and microwave components. **7.** Circuit design, electrical power, armament control and IR subsystems, navigation and target tracking systems. **8.** Aircraft display and controls, human factors and electronic packaging.

Education: B.S. in E.E., M.E. or Physics. Applicants should be articulate in writing and communication as related to their responsibilities. U. S. citizenship required.

For immediate consideration, please airmail your resume to:

MR. ROBERT A. MARTIN
Head of Employment
Hughes Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 48, California

Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS

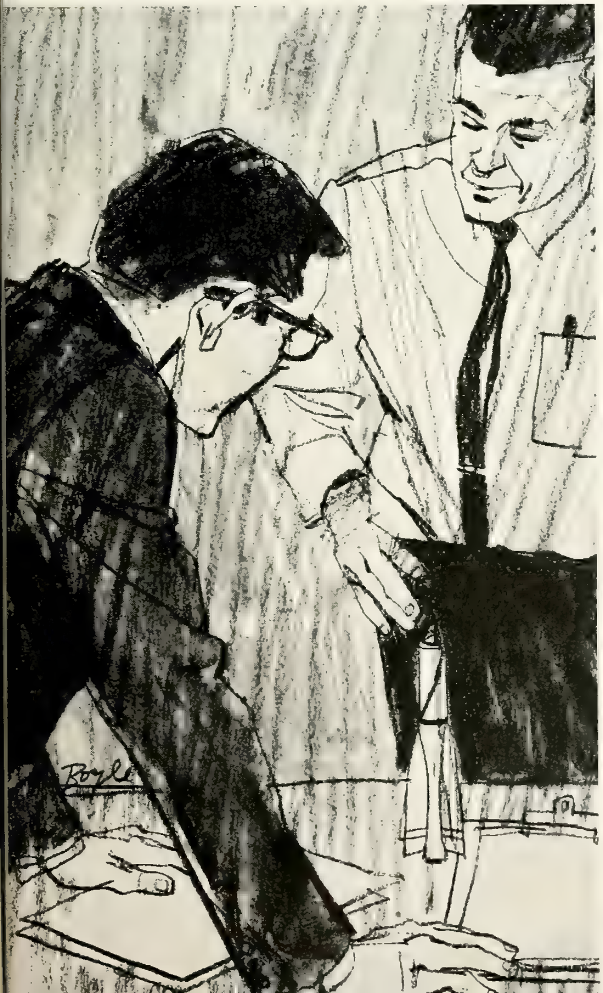
An equal opportunity employer

MISSILE SYSTEM FUNCTIONAL DESIGN

Responsibilities: Determine functional design requirements for advanced air-launched missiles; the design of such systems to meet customer requirements and theoretical analysis of system performance; coordinate and assist engineering departments in the development of equipment to fulfill the system requirements.

Experience: Two years minimum in one or more of the following fields: **1.** System engineering on missile or fire control systems. **2.** Field engineering on airborne fire control systems or missile systems. **3.** Test and evaluation of comparable systems. **4.** Radar systems (pulse doppler). **5.** Target tracking systems. **6.** Autopilot and control systems. **7.** Microwave systems. **8.** Digital computers. **9.** Navigation systems. **10.** Inertial components. **11.** Electrical power and armament control subsystems. **12.** Circuit design and electronic packaging.

Education: B.S. in E.E., M.E. or Physics. Articulate in communications. U.S. citizenship required.

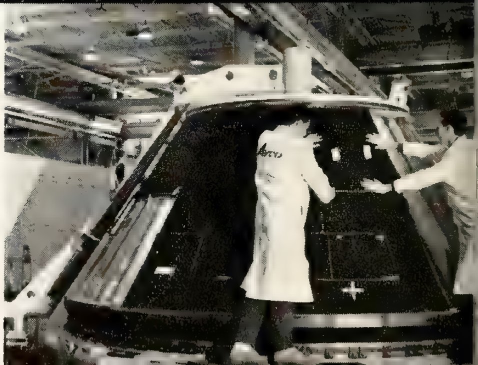


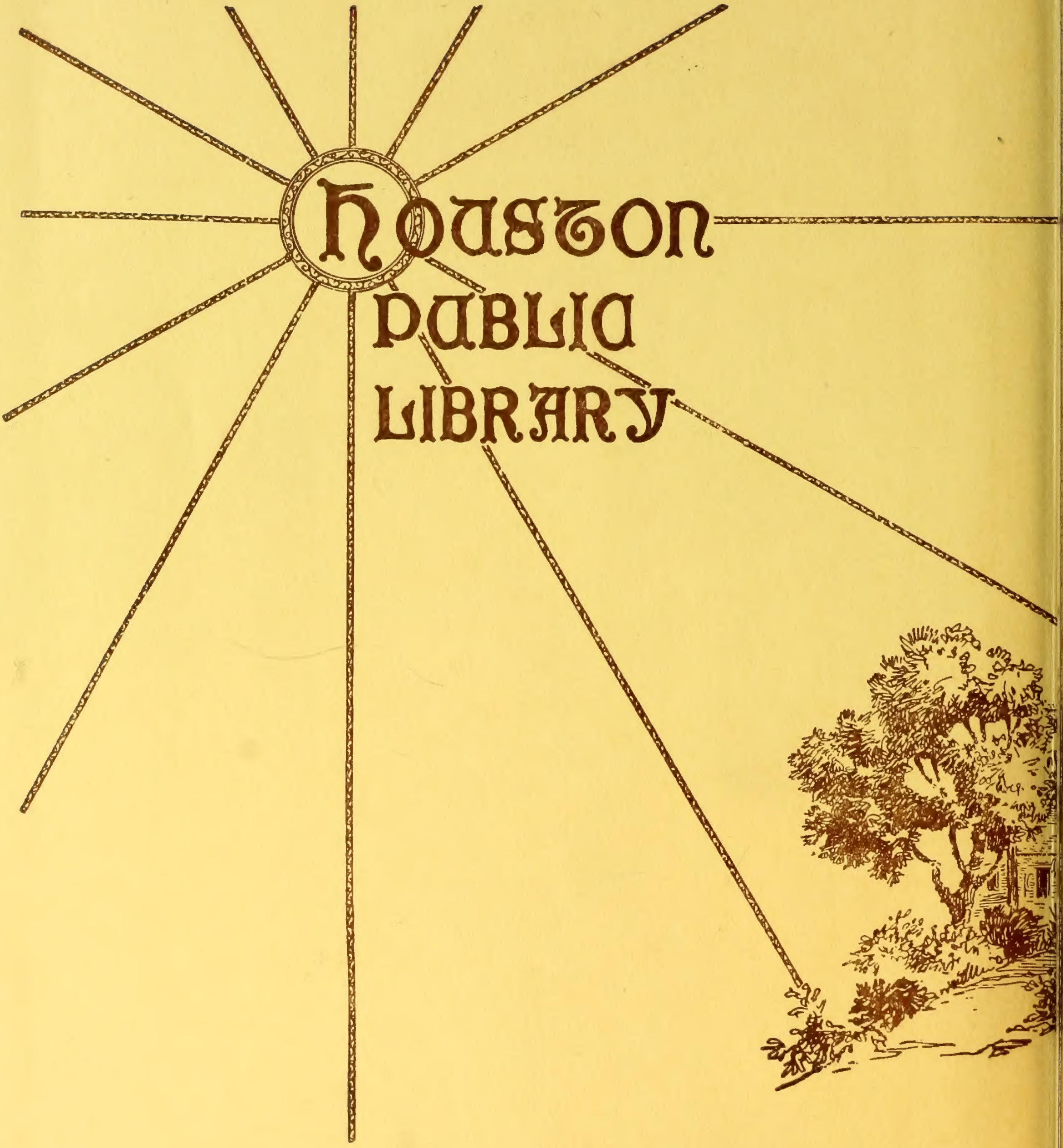
Apollo Re-entry

From materials research to heat-shield fabrication—
At Avco/RAD the job only begins with research. Our scientists solved the problem of finding materials which could travel for weeks in the deep cold of outer space, then survive the tremendous heat and pressure generated by 25,000 mile-an-hour re-entry. But North American Aviation's assignment to Avco/RAD didn't end with research. We are also designing and manufacturing the unique Apollo Command Module thermal protection system upon which will depend the lives of the first three Americans returning from the moon. Furthermore, this concept-to-hardware process is guided by a veteran program-management team meeting tight cost and schedule requirements. Having capabilities like this "under one roof" is what we mean when we say: *Avco/RAD is an integrated research and development organization.*

AVCO/RAD

AVCO CORPORATION/RESEARCH AND ADVANCED DEVELOPMENT DIVISION/WILMINGTON, MASSACHUSETTS




HOUSTON
PUBLIC
LIBRARY